DOCUMENT RESUME

ED 267 286 CE 043 986

AUTHOR	Brown, A. O., III; Fulkerson, Dan, Ed.
TITLE	Advanced Microcomputer Service Technician. Teacher Edition.
INSTITUTION	Mid-America Vocational Curriculum Consortium, Stillwater, Okla.
PUB DATE	85
NOTE	419p.; For related documents, see CE 043 985-987. Use of colored paper may affect reproducibility.
AVAILABLE FROM	Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074 (Catalog No. 600901--$30.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Classroom Techniques; *Computer Science; Computer Science Education; Electronics; Equipment Maintenance; Hand Tools; *Job Skills; *Microcomputers; Paraprofessional Personnel; Postsecondary Education; Problem Solving; *Repair; Service Workers; Technical Education; Visual Aids

ABSTRACT

This manual is the second of a three-text microcomputer service and repair series. This text addresses the training needs of "chip level" technicians who work with digital troubleshooting instruments to solve the complex microcomputer problems that are sent to them from computer stores that do not have full-service facilities. The manual contains 11 units. Each instructional unit includes some or all of the basic components: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction. (This teacher's edition contains materials suitable for reproduction and hand-outs to students.) Units cover the following topics: fundamentals of microprocessors; system architecture; microprocessor architecture and timing; tools and test equipment; busses, protocols, and handshakes; generic troubleshooting; and troubleshooting the Apple II, Commodore 64, IBM PC, Zenith Z-100, and TRS-80 microcomputers. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

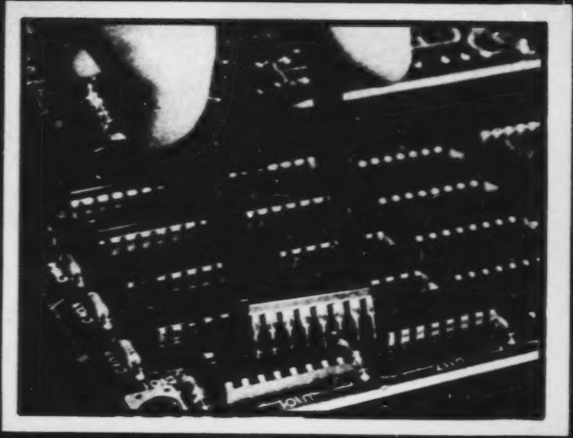
- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

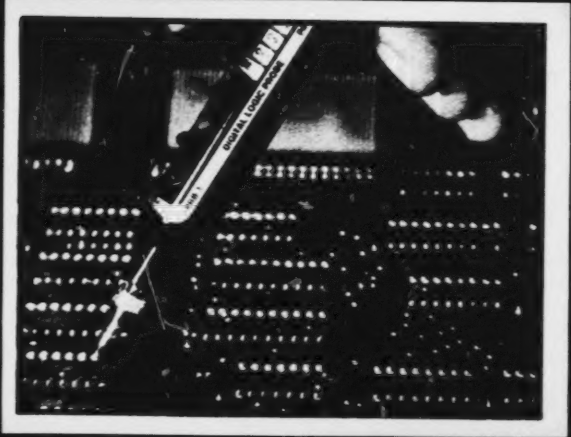
"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

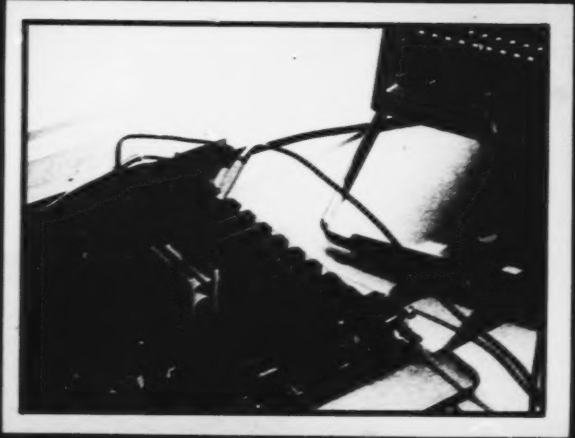
Dean

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED267286

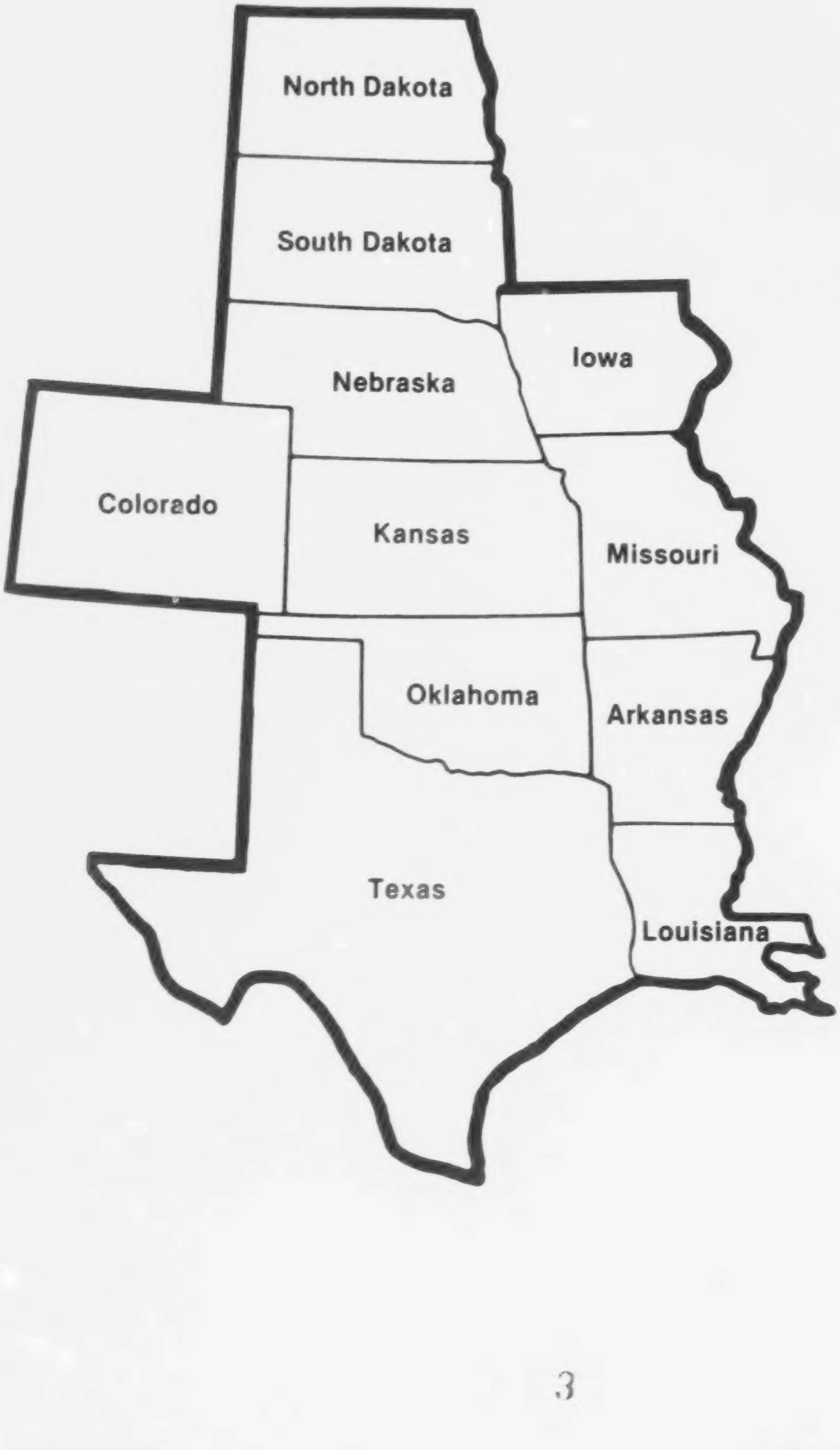






MAVCC
MAVCC
MAVCC
MAVCC

MID-AMERICA
VOCATIONAL
CURRICULUM
CONSORTIUM


North Dakota
South Dakota
Nebraska
Iowa
Colorado
Kansas
Missouri
Oklahoma
Arkansas
Texas
Louisiana

ADVANCED MICROCOMPUTER SERVICE TECHNICIAN

Written by

Dr. A. O. Brown III

Edited by

Dan Fulkerson

Developed by
the

Mid-America Vocational Curriculum Consortium, Inc.

Board of Directors

James Dasher, Arkansas, Chairman
Les Abel, Kansas, Vice Chairman
Wiley Lewis, Colorado, Parliamentarian
John Van Ast, Iowa
David Poston, Louisiana
Harley Schlichting, Missouri
Merle Rudebusch, Nebraska
Ron Mehrer, North Dakota
Bob Patton, Oklahoma
Larry Lyngstad, South Dakota
Pat Lindley, Texas
Greg Pierce, Executive Director

86-003273

CN600901

©1985 by the Mid-America Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book
may be reproduced in any form or by any
means without written permission from the publisher.

Printed in the United States of America by the
Oklahoma State Department of Vocational-Technical Education
Stillwater, Oklahoma 74074-4364

Mid-America Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

ADVANCED MICROCOMPUTER SERVICE TECHNICIAN

TABLE OF CONTENTS

Unit I: Fundamentals of Microprocessors 1

Unit II: System Architecture 43

Unit III: Microprocessor Architecture and Timing 79

Unit IV: Tools and Test Equipment 183

Unit V: Busses, Protocols, and Handshakes 219

Unit VI: Generic Troubleshooting 273

Unit VII: Troubleshooting the Apple II® Microcomputer 315

Unit VIII: Troubleshooting the Commodore® 64 Microcomputer 359

Unit IX: Troubleshooting the IBM® PC 391

Unit X: Troubleshooting the Zenith® Z-100 Microcomputer 417

Unit XI: Troubleshooting the TRS-80® Microcomputer 443

Introductory pages xxxi through xxxvi include important information about schematics and other graphic aids recommended for the troubleshooting units in this text — be sure to read that information!

6

FOREWORD

Advanced Microcomputer Service Technician is an excellent text. In fact it is so good that students who want to tackle it should go armed with a background in electricity, electronics, and digital electronics. Good skills in soldering and desoldering are also required to successfully master this second text of MAVCC's microcomputer service series.

There may be no such thing as an ideal text for any course, but *Advanced Microcomputer Service Technician* comes close to filling the bill. The concluding units of the text address the troubleshooting and repair of five of the most popular brands of microcomputers — The Apple II®, the Commodore® 64, the TRS-80®, the IBM® PC, and the Zenith® Z-100. In other words, the text covers the kinds of microcomputers that most schools are using. So, as students learn, they can dedicate that effort to keeping the school's microcomputers in top-notch operating condition.

Truth is, we feel that the entire three-text series from MAVCC will answer the needs for the high-tech materials that electronics instructors everywhere have been looking for.

James Dasher, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

Advanced Microcomputer Service Technician is the second of MAVCC's three-text microcomputer service and repair series. This text addresses the training needs of "chip level" technicians who work with digital troubleshooting instruments to solve the complex microcomputer problems that are sent to them from computer stores who do not have full service facilities.

Basic Microcomputer Service Technician is the introductory book to the series and really should be taught prior to the advanced text. The third text, *Microcomputer Peripheral Service Technician* can fit in at almost any point in a good electronics program. It presents service and repair procedures for floppy disk drives, printers, and monitors, and is the ideal book for basic technicians who want to expand their skills or advanced technicians who want to specialize in peripheral repair.

The Bureau of Labor Statistics predicts a healthy job market for microcomputer service technicians at all levels for many years to come. The MAVCC microcomputer repair series is dedicated to filling the training needs of electronics programs that want to keep pace with high technology now and in the future.

Greg Pierce
Executive Director
Mid-America Vocational
Curriculum Consortium

8

ACKNOWLEDGEMENTS

Appreciation is extended to the many individuals who contributed their time and expertise to the successful development of *Advanced Microcomputer Service Technician.* The Resource Committee which planned and approved the text included outstanding electronics instructors from MAVCC member states, representatives from the microcomputer service industry, and even a computer store owner. A special thank you goes to the members of the Resource Committee:

Charles Black, Shreveport-Bossier Vo-Tech, Shreveport, Louisiana
Bob Chenoweth, Chillocothe Vocational Technical School, Chillocothe, Missouri
Jerry Farrell, Hawkeye Institute of Technology, Waterloo, Iowa
Bill Gandy, Digital Equipment Corporation, Denver, Colorado
Robert Griffith, Southeast Vo-Tech Institute, Sioux Falls, South Dakota
Mohammed Hague, Kansas City Community College, Kansas City, Kansas
Ed Harper, Zenith Distribution Company, Lenaxa, Kansas
David Larsen, The Blacksburg Group, Inc., Blacksburg, Virginia
Noel Laxdeal, Computerland, Bismarck, North Dakota
Herman Morrison, Delta Vo-Tech, Truman, Arkansas
Rick Morrow, Tri-County Area Vo-Tech School, Bartlesville, Oklahoma
Eddie Palovik, State Department of Vo-Tech Education, Stillwater, Oklahoma
Gus Rummel, Central Texas College, Killeen, Texas
Ron Vorderstrasse, Central Community College, Columbus, Nebraska

Another special thank you goes to **Dr. A. O. Brown III** of Pittsburg, Kansas, for a splendid job of writing the text and also for his contributions as a member of the Resource Committee.

Appreciation is also extended to Dan Fulkerson, MAVCC's Publications Coordinator, for his contributions as editor of the project, and to Mary Kellum and Jane Huston of MAVCC for editing assistance.

A special appreciation goes out to Damon Davis and to the publishers Howard W. Sams & Co., Inc., for their active support of the project and for materials contributed to the project.

A concluding thank you goes to many people in the industry who took time to talk to the writer and editorial staff on the phone, and to assist with other technical matters in correspondence. Engineers, Service Managers, and Customer Service personnel from many companies are among the list that is too numerous to include here, but a collective thank you goes to all of them.

The text was phototypeset in the Oklahoma State Vo-Tech Communications Center, and for her dedicated contribution, appreciation is extended to the phototypesetter Leslie Mathis.

Another vote of thanks goes to the personnel of the Oklahoma State Vo-Tech Print Shop for their excellent work in printing the text.

USE OF THIS PUBLICATION

Instructional Units

Advanced Microcomputer Service Technician includes eleven units. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

  1. Supplies needed
  2. Equipment needed
  3. Amount of practice needed
  4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

ADVANCED MICROCOMPUTER SERVICE TECHNICIAN

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT I: FUNDAMENTALS OF MICROPROCESSORS

1. Terms and definitions
2. Electricity/electronics areas and their definitions
3. Student prerequisites
4. Sections of a microprocessor
5. Buffers and how they work
6. Microprocessor architecture and information flow
7. Decoding techniques and their characteristics
8. Other functions of the control section
9. General functions of registers
10. The ALU and its functions
11. Specific registers and their functions
12. Status bits or flags and their functions
13. Invisible registers and what they do
14. Busses and what they do
15. The clock and clock circuitry
16. Stack operations
17. Interrupts and how they work

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	18. I/O devices and their functions
	19. Structured programming and its objective
	20. Programming models and their uses
	21. Memory mapping
	22. Programming activities and their functions
23. Solve problems concerning microprocessor operations	
24. Fill in a block diagram of a microprocessor	

UNIT II: SYSTEM ARCHITECTURE

	1. Terms and definitions
	2. Memory mapping
	3. Importance of microprocessor control functions
	4. Busses on a typical microcomputer
	5. Characteristics of the data bus
	6. Characteristics of the address bus
	7. Characteristics of the control bus
	8. Characteristics of the system bus
	9. Busses and I/O relationships
	10. ROM's and their characteristics
	11. Read/write memories (RAM's) and their characteristics

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	12. Timing circuits
	13. Clock signals
	14. Clock phases
	15. Other timing signals
16. Solve problems related to system architecture and bus activity	
17. Diagram the relationship between the microprocessor and other system components in typical system architecture	

UNIT III: MICROPROCESSOR ARCHITECTURE AND TIMING

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Major elements of microprocessor architecture
	3. Architecture of the 6502 microprocessor
	4. Electrical characteristics of the 6502
	5. Architectural features of the 6502
	6. Architecture of the 8080A microprocessor
	7. Electrical characteristics of the 8080A
	8. Architectural features of the 8080A
	9. Comparisons between the 8080A and the 8085 microprocessors
	10. Architecture of the Z-80 microprocessor
	11. Features that enhance Z-80 performance
	12. Electrical characteristics of the Z-80
	13. Architecture features of the Z-80
	14. Architecture of the 6800 microprocessor

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

15. Electrical characteristics of the 6800
16. Architectural features of the 6800
17. Comparisons of the 6800 and 6802 microprocessors
18. Architecture of the 8088 microprocessor
19. Characteristics of the 8088 group registers
20. The 8088 instruction set
21. The significance of timing functions
22. Waveform interpretations
23. Other signals related to clock timing
24. Line diagram of 6502 clock timing
25. Typical 6500/6800 cycle for reading data from memory or peripherals
26. Typical 6500/6800 cycle for writing data to memory or peripherals
27. Instruction sets
28. Instructions that move data
29. Instructions for internal transfer
30. Instructions for arithmetic and logic functions
31. Instructions for decision making
32. Instructions for comparison
33. Instructions for indexing
34. Instructions for internal operations
35. Instructions for special operations
36. Addressing modes
37. Addressing modes and their characteristics

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	38. Interrupts and how they work
	39. Types of interrupts
	40. The OPCODE and operands
41. Write and run a machine language driver program to check a read/write memory (RAM) location	
42. Write and run a driver program for making expanded read/write memory (RAM) checks	

UNIT IV: TOOLS AND TEST EQUIPMENT

1. Terms and definitions
2. Standard hand tools for microcomputer repair
3. Special tools for handling IC's
4. Soldering equipment
5. Lubrication tools and materials
6. Adhesives and sealants
7. Inspection and cleaning tools
8. Static control devices
9. Tools kits
10. Other specialty tools and equipment
11. Power supplies
12. Electronics test instruments and their typical uses
13. Special test instruments and their characteristics
14. DVOM operations
15. Oscilloscope operations

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	16. Data analyzer operations
	17. Emulator operations
18. Use a DVOM to test a microcomputer system bus	
19. Use an oscilloscope to check a microcomputer clock signal	
20. Use a frequency meter to check the clock frequency on a microcomputer system bus	

UNIT V: BUSSES, PROTOCOLS, AND HANDSHAKES

1. Terms and definitions
2. System busses and their characteristics
3. Types of system busses
4. Types of application cards for system busses
5. Signal groups in a system bus
6. Using the system bus as a troubleshooting tool
7. Typical system busses
8. General information about the IBM® PC bus
9. Power supply pins on the IBM® PC bus
10. Timing signals on the IBM® PC bus
11. Control signals on the IBM® PC bus
12. DMA control signals on the IBM® PC bus
13. General information about the Apple II® bus
14. Timing signals on the Apple II® bus
15. Power supply pins on the Apple II® bus
16. Control and line signals on the Apple II® bus
17. DMA and interrupt signals on the Apple II® bus

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	18. Color signals on the Apple II® bus
	19. General information about the TRS-80® bus
	20. Data and address line signals on the TRS-80® bus
	21. Control signals on the TRS-80® bus
	22. Electrical signals on the TRS-80® bus
	23. Other types of busses and their characteristics
	24. The RS-232-C standard
	25. Electrical parameters for the RS-232 standard
	26. Typical steps in an RS-232 communication
	27. Parity and how it works
	28. Mechanical specifications for the RS-232
	29. EIA pin specifications for the RS-232
	30. RS-232 relationships with DCE and DTE devices
	31. The centronics standard
	32. Pin arrangements for the centronics standard
	33. Typical steps in a centronics communication
	34. Types of cables used with the RS-232 and centronics standards
	35. Cable assembly techniques
	36. Special tools required for cable assembly
	37. Special materials for cable assembly
	38. Steps in documenting cable assembly
39. Assemble an RS-232 cable connector	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT VI: GENERIC TROUBLESHOOTING

	1. Terms and definitions
	2. First rules for advanced troubleshooting
	3. Troubleshooting preliminaries
	4. The rationale and order of systematic troubleshooting
	5. Other elements of systematic troubleshooting
	6. Habits that promote better troubleshooting
	7. Graphic materials and their uses in troubleshooting
	8. Block diagrams and their characteristics
	9. Schematics and their characteristics
	10. Other graphic aids for troubleshooting guides
	11. Schematics and troubleshooting guides
12. Read and interpret parts of a Computerfacts™ schematic	
13. Cut and desolder pins and remove a chip from a printed circuit board	

UNIT VII: TROUBLESHOOTING THE APPLE II® MICROCOMPUTER

	1. Terms and definitions
	2. Troubleshooting the power supply
	3. Other power supply checks
	4. Troubleshooting the clock
	5. Repairing a faulty clock
	6. Troubleshooting control lines
	7. Steps in determining when to substitute a microprocessor
	8. Troubleshooting ROM

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	9. Troubleshooting RAM
	10. Troubleshooting I/O functions
	11. Characteristics of the keyboard and interface components
	12. Troubleshooting the keyboard and components
	13. Time-saving routines for troubleshooting a keyboard
	14. Troubleshooting video I/O
	15. Troubleshooting video components
	16. Troubleshooting video color problems
	17. Troubleshooting audio problems
	18. Troubleshooting cassette tape I/O
19. Prepare an Apple microcomputer for troubleshooting	
20. Troubleshoot the power supply on an Apple microcomputer	
21. Troubleshoot the main board on an Apple microcomputer	

UNIT VIII: TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER

	1. Basic system characteristics of the C-64
	2. C-64 component characteristics
	3. Tips for initial troubleshooting
	4. Special problems in troubleshooting the C-64
	5. How to evaluate C-64 board repair charges

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
6. Troubleshoot the power supply and check operating voltages on a C-64 microcomputer	
7. Troubleshoot the main board on a C-64 microcomputer	

UNIT IX: TROUBLESHOOTING THE IBM® PC

JOB TRAINING	RELATED INFORMATION
	1. System characteristics of the IBM® PC
	2. Component characteristics of the IBM® PC
	3. Materials for troubleshooting
	4. Tips for troubleshooting the IBM® PC
5. Troubleshoot the power supply and operating voltages on an IBM® PC	
6. Troubleshoot the main board on an IBM® PC	

UNIT X: TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER

JOB TRAINING	RELATED INFORMATION
	1. Basic Z-100 configurations
	2. System characteristics of the Z-100
	3. Component characteristics of the Z-100
	4. Guidelines for troubleshooting the Z-100
5. Troubleshoot the power supply and operating voltages on a Z-100 microcomputer	
6. Troubleshoot the main board on a Zenith Z-100 microcomputer	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT XI: TROUBLESHOOTING THE TRS-80® MODEL III MICROCOMPUTER

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. System characteristics of the Model III
	3. Component characteristics of the Model III
	4. Troubleshooting guidelines for the Model III
5. Disassemble a TRS-80® Model III microcomputer	
6. Troubleshoot the power supply on a TRS-80® Model III microcomputer	
7. Troubleshoot the main board on a TRS-80® microcomputer	

ADVANCED MICROCOMPUTER SERVICE TECHNICIAN

Tools, Equipment, and Materials List

Standard hand tools

Assorted flatblade and Phillips screwdrivers
Jeweler's screwdriver
Nutdriver set (3/16" to 1/2")
Hexagonal wrenches (1/16" to 1/4")
Combination open-end, box-end wrenches (1/16" to 1/4")
Round and flat files
Standard slip joint pliers
Needlenose pliers
Flat, duckbill-type pliers
Diagonal cutting pliers
Reversible snap-ring pliers
Wire strippers
Crimping tool
Small hammer with lucite head

Soldering equipment

Soldering iron (25 to 60 watts)
Soldering stand or station
Desoldering tool (piston-loaded or bulb type)
Desoldering wick
Soldering tip cleaning sponge
Resin-cored solder in large and small diameters

Tools for handling integrated circuits

Chip extractor and inserter
Tweezers
Hemostat (forceps)
16-pin, 28-pin, and 40-pin dual-in-line-package test clips

General tools and supplies

Plastic oiling bottle with leak-proof spout
Precision oiler
High-quality machine oil
Teflon-based lubricant
Graphite-based lubricant
Adhesives and sealants as specified by OEM requirements
Small flashlight
Inspection mirror (dental type)
Small brushes
Small battery operated DC vacuum cleaner
Spray can cleaner
Static mat and wrist band
Static foam
Surge protectors
Cables and connectors
Shrink tubing
Heat gun
Set of small precision knives
Miscellaneous clips, wires, nuts, and bolts

Electronic devices and test instruments

Multi-range power supply (0V to 25V)
Small, high current power supply (5V)
DVOM (or VOM)
Oscilloscope (dual-trace, 60 MHz)
Logic probe
Logic pulsar
Current tracer
Frequency meter (optional)
Signature analyzer (optional)
Data analyzer (optional)
Floppy disk analyzer (optional)
Emulator (optional)
Extender card

Reference materials

Computerfacts™ as required
OEM technical materials as available

ALPHABETICAL LIST OF REFERENCES USED IN DEVELOPING THIS TEXT

A. *Apple II DOS User's Manual.* Cupertino, CA 95014: Apple Computer, Inc., 1984.

B. *Apple II 80-Column Text Card Manual.* Cupertino, CA 95014: Apple Computer, Inc., 1984.

C. *Black Box Catalog of Data Communications and Computer Devices.* Pittsburg, PA 15241: Black Box Corporation, July 1985.

D. Brenner, Robert C. *IBM PC Troubleshooting and Repair Guide.* Indianapolis, IN 46268: Howard W. Sams and Co., Inc., 1985.

E. Brey, Barry D. *Microprocessor/Hardware Interfacing and Applications.* Columbus, OH 43216: Charles E. Merrill Publishing Company, 1984.

F. Camp, R.C., and T.A. Smay and C.J. Triska. *Microprocessor Systems Engineering.* Portland, OR 97210: Dilithium Press, 1981.

G. *Commodore Programmer's Reference Guide.* Wayne, PA 19087: Commodore Business Machines, Inc., 1982.

H. *Commodore User's Guide.* Wayne, PA 19087: Commodore Business Machines, Inc., 1982.

I. *Component Data Catalog.* Santa Clara, CA 95051: Intel Corporation, 1982.

J. *Disk System Owner's Manual.* Fort Worth, TX 76102: Tandy Corporation, 1980.

K. Drischoll, Frederick F. *Microprocessor-Microcomputer Technology.* North Scituate, MA 02060: Breton Publishers, a division of Wadsworth, Inc., 1983.

L. *IPAX 86, 88 User's Manual.* Santa Clara, CA 95051: Intel Corporation, 1981.

M. Johnston, Chris. *The Microcomputer Builder's Bible.* Blue Ridge Summit, PA 17214: Tab Books, Inc., 1982.

N. Kershaw, John D. *Digital Electronics Logic and Systems, Second Edition.* Belmont, CA 94002: Breton Publishers, a Division of Wadsworth, Inc., 1983.

O. *MCS6500 Microcomputer Family Hardware Manual.* Norristown, PA 19401: MOS Technology, Inc., 1976.

P. *MCS6500 Microcomputer Programming Manual.* Norristown, PA 19401: MOS Technology, Inc., 1976.

Q. Peatman, John B. *Microcomputer-Based Design*. New York, NY: McGraw-Hill Book Company, 1977.

R. Poe, Elmer C., and James C. Goodwin. *The S-100 and Other Micro Busses*. Indianapolis, IN 46268: Howard W. Sams & Co., 1979.

S. *SAMS Computerfacts™ CC1, COMPUTER: Apple II®, Apple II+®*. Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1984.

T. *SAMS Computerfacts™ CC4, COMPUTER: Commodore® 64*. Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1984.

U. *SAMS Computerfacts™ CC5, COMPUTER: Atara 400™*. Indianapolis, IN 46206: Howard W. Sams & Co, Inc., 1984.

V. *SAMS Computerfacts™ CSCS2 COMPUTER: IBM® PC5150*. Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1985.

W. *SAMS Computerfacts™ CSCS4 COMPUTER: TRS-80® III*. Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1985.

X. Stephenson, John, and Bob Cahill. *How to Maintain and Service Your Small Computer*. Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1983.

Y. *The IC Troubleshooters, New Techniques of Digital Troubleshooting, Applications Note 163-2*. Palo Alto, CA 94304: Hewlett-Packard, No date.

Z. Tocci, Ronald J., and Lester P. Laskowski. *Microprocessors and Microcomputers*. Englewood Cliffs, NJ 07632: Prentice-Hall, Inc., 1979.

AA. *TRS-80® Model III Technical Reference Manual for Programmers and Technicians*. Fort Worth, TX 76102: Tandy Corporation, 1981.

BB. Zumchak, Eugene. *Microcomputer Design and Troubleshooting*. Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1982.

CC. *Z-100 User's Manual*. Saint Joseph, MI 49085: Zenith Data Systems, 1982.

Important Information: Read Carefully!

Since schematics and other graphics vital to troubleshooting are not readily available from some manufacturers, SAMS Computerfacts™ published by Howard W. Sams are recommended materials for troubleshooting all popular brands of microcomputers, disk drives, printers, and monitors. They are especially recommended as complementary materials for the troubleshooting units in this text.

These Computerfacts™ are available from Howard W. Sams & Co., Inc., 4300 West 62nd Street, P.O. Box 7092, Indianapolis, Indiana, 46268. Orders for Computerfacts™ may also be placed toll free by calling 1-800-428-SAMS, or 1-800-298-5566.

On the following pages are listed the currently available Computerfacts™ for popular brands of microcomputers, disk drives, printers, and monitors. The final page is a list of Computerfacts™ that should be available soon. Any questions about microcomputers or peripherals not listed should be directed to Howard W. Sams or called in to one of the toll free numbers listed above.

By special arrangement with Howard W. Sams, MAVCC is able to make the Computerfacts™ for this text available as a single package with an impressive educational discount. The Computerfacts™ in this special package include CC-1 for the Apple II® and Apple II+®; CC-4 for the Commodore® 64; CSCS-2 for the complete IBM® PC 5150 system; and CSCS-5 for the complete TRS-80® III system. If purchased separately at list price, items in this package would total more than $115. For an impressive educational discount, call MAVCC toll free at 1-800-654-3988. Single items from the special package may also be purchased with the educational discount, but individual handling slightly increases the cost. Call MAVCC toll free at 1-800-654-3988 for prices and shipping information.

Computers: Available Computerfacts™

Computer(s)	Set Number	List Price*
Apple II, II+	CC-1	17.95
Apple IIe	CC-10	19.95
Atari 400	CC-5	17.95
Atari 800	CC-7	17.95
Commodore 64	CC-4	17.95
Commodore C-16	CC-8	17.95
Commodore VIC 20	CC-3	17.95
Commodore Plus/4	CC-9	19.95
Epson QX-10 (Dual disk drives and monitor)	CSCS-4	39.95
Franklin Ace 100	CC-6	17.95
IBM PC 5150 (Dual disk drives)	CSCS-2	39.95
Osborne OCC1,OCC1A (Disk drive and monitor)	CSCS-1	39.95
TI-994/A	CC-2	17.95
TRS-80 I (Level II) (Disk drive and monitor)	CSCS-3	39.95
TRS-80 III (Disk drive and monitor)	CSCS-5	39.95

*Prices are subject to change

Disk Drives: Available Computerfacts™

Disk Drive(s)	Set Number	List Price*
Apple II A2M0003	CD-6	19.95
Commodore 1541 and VIC 1541	CD-4	17.95
Rana Elite I	CD-3	17.95
Rana Elite II	CD-2	17.95
Rana Elite III	CD-1	17.95
TRS-80 261164 A	CD-5	19.95
TRS-80 261160, 61	CD-7	19.95

*Prices are subject to change

Printers: Available Computerfacts™

Printer	Set Number	List Price*
Apple Imagewriter	CP-8	19.95
Commodore 1525	CP-4	17.95
Epson FX 80	CP-7	19.95
Epson MX 80 F/T	CP-1	17.95
Epson MX 100	CP-2	17.95
Epson RX 80	CP-9	19.95
IBM 5152-002	CP-3	17.95
NEC PC8025A	CP-5	17.95
TRS-80 DMP-120	CP-6	19.95

*Prices are subject to change

Monitors: Available Computerfacts™

Monitor(s)	Set Number	List Price*
Amdek Color 1 and Amdek Video 300	CMT-3	17.95
Hitachi CM1481 and Panasonic CT-1310M	CMT-1	17.95
IBM 5151 Color and IBM 5153 Monochrome	CMT-4	17.95
Panasonic CT-1320M and Zenith ZVM122A/123A	CMT-5	17.95
Panasonic CT-1350MG and Zenith ZVM-121	CMT-2	17.95
Panasonic CT-1920M and Sanyo AVM 196	CMT-6	17.95

*Prices are subject to change

Other Computerfacts™ in the planning or development stages

Computers

Apple IIc
Atari 800 XL
IBM PC Jr
Macintosh
Zenith Z150
Zenith Z160

Printers

Commodore 4023
C Itoh 8510 AP
Epson FX100
Gimini 10X
Gimini 15X
NEC 3510
NEC 8023A
Okidata 80

(NOTE: This is only a partial listing, and all inquiries concerning Computerfacts™ development should be directed to the company address or called in to the toll free telephone numbers listed. Executives at Howard W. Sams have indicated that microcomputers or peripherals not on the SAMS development schedule will be placed there if significant need is evidenced from instructors or other professionals who may require them.)

33

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list prerequisites for students of advanced microcomputer repair and trace microcomputer operations through the microprocessor, the ALU, the registers, and other components of a microcomputer system. These competencies will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to fundamentals of microprocessors with their correct definitions.
2. Match electricity/electronics areas with their definitions.
3. Complete statements concerning student prerequisites.
4. Complete statements concerning sections of a microprocessor.
5. Select true statements concerning buffers and how they work.
6. Solve problems concerning microprocessor architecture and information flow.
7. Solve problems concerning decoding techniques and their characteristics.
8. Complete statements concerning other functions of the control section.
9. Complete statements concerning general functions of registers.
10. Complete statements concerning the ALU and its functions.

OBJECTIVE SHEET

11. Match specific registers with their functions.
12. Match status bits or flags with their functions.
13. Complete statements concerning invisible registers and what they do.
14. Complete statements concerning busses and what they do.
15. Solve problems concerning the clock and clock circuitry.
16. Complete statements concerning stack operations.
17. Complete statements concerning interrupts and how they work.
18. Complete statements concerning I/O devices and their functions.
19. Solve problems concerning structured programming and its objective.
20. Complete statements concerning programming models and their uses.
21. Complete statements concerning memory mapping.
22. Match programming activities with their functions.
23. Solve problems concerning microprocessor operations. (Assignment Sheet #1)
24. Fill in a block diagram of a microprocessor. (Assignment Sheet #2)

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and assignment sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information and assignment sheets.

F. Impress upon students the significance of the microprocessor in system operations, and how the operations or lack of operations are related to elements of troubleshooting.

G. Use TM 1 to demonstrate both microprocessor structure and information flow through a microprocessor, and remind students that one of the assignment sheets is patterned after the block diagram in TM 1.

H. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Transparency masters

    1. TM 1 — Microprocessor Block Diagram

    2. TM 2 — Memory Map

    3. TM 3 — Loop on Fail Flowchart

D. Assignment sheets

    1. Assignment Sheet #1 — Solve Problems Concerning Microprocessor Operations

    2. Assignment Sheet #2 — Fill in a Block Diagram of a Microprocessor

E. Answers to assignment sheets

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Kershaw, John D. *Digital Electronics Logic and Systems* (Second Edition). Belmont, CA 94002: Breton Publishers, a Division of Wadsworth, Inc., 1983.

B. Peatman, John B. *Microcomputer-Based Design.* New York, NY: McGraw-Hill Book Company, 1977.

C. Driscoll, Frederick F. *Microprocessor-Microcomputer Technology.* Belmont, CA 94002: Breton Publishers, a Division of Wadsworth, Inc., 1983.

D. *Component Data Catalog.* Santa Clara, CA 95051: Intel Corporation, 1982.

E. *MCS6500 Microcomputer Family Hardware Manual.* Norristown, PA 19401: MOS Technology, Inc., 1976.

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

INFORMATION SHEET

I. **Terms and definitions**

A. Address word — A binary word that the microprocessor uses as an address to determine the location of a memory or I/O word

B. Data word — A binary word that the microprocessor manipulates internally by moving, storing, or operating on the word to obtain a desired result

C. Crystal — An electronic component that is used to precisely time events in a device such as a microprocessor

(NOTE: On schematics, crystal is frequently abbreviated as Xtal.)

D. Incrementing — Increasing the contents of an address or register by one

E. Decrementing — Decreasing the contents of an address or register by one

F. Latch — An electronic device capable of holding a predetermined electrical condition

Example: Just as a door latch is locked or unlocked, an electronic latch is either 0 or 1, and if an 8-bit data word is latched, it would mean that all bits are simultaneously held at their proper electrical levels

G. Least significant bit — The bit that represents the lowest digit in a binary number or the bit to the far right

H. Most significant bit — The bit that represents the highest digit in a binary number or the bit to the far left

I. Synchronous — The timing of a bit or binary word so that it coincides with a precisely timed signal source

Example: the data and address words are said to be synchronous with the microprocessor waveforms

J. Asynchronous — The condition in which the timing of a bit or binary word does not coincide with the signal source used in the system

Example: RS-232 signals are typically asynchronous because the signals are generated external to the microprocessor

K. Queue — A means of identifying the procedure of placing bits or words of binary information in sequence

Example: It's like standing in line at a bus stop or movie for your turn to get on board or to buy a ticket

INFORMATION SHEET

II. **Electricity/electronics areas and their definitions**

A. Basic electricity — The study of basic laws, basic circuitry, basic instrumentation, and generally the fundamental principles that underlie electricity and its applications

B. Basic electronics — The study of electrical controls, the transistors and other devices used in control circuitry, and the operation and troubleshooting of control circuitry as it is used in power supplies, amplifiers, and other control devices

C. Digital electronics — The study of electronics that studies the use of nonlinear binary-type signals used in logic and computing circuitry and how these circuits function in microcomputers, microcontrollers, and other control devices

III. **Student prerequisites**

A. Students using this text require basic skills in electricity, electronics, and digital electronics as well as general skills in computer operations

B. Students using this text should also know how to properly use hand tools and test equipment needed in the troubleshooting and repair of microcomputer systems

C. Students hoping to succeed as advanced microcomputer repair technicians should already have or should develop superior skills in desoldering and soldering

D. Students of advanced computer repair should review troubleshooting procedure required for basic system service and pay special attention to items concerning record keeping

(NOTE: MAVCC's *Basic Microcomputer Service Technician* is recommended for beginning service technicians and for students in advanced service classes who have not studied basic computer service requirements.)

IV. **Sections of a microprocessor** (Transparency 1)

A. Control section — Contains the input register, the decoder for decoding instructions, the timing circuitry, and the interrupt circuitry

B. Register section — Contains the ALU and all the working registers:

(NOTE: Invisible registers that cannot be accessed by a programmer are treated in a later objective.)

1. Program counter
2. Index registers

INFORMATION SHEET

3. Accumulators

4. Stack pointers

5. Status or flag register

   (NOTE: The status or flag register is often considered part of the ALU, but it is often referred to by the decoder and the control section during many decoding operations, and is connected via various buffers to the address bus in the system and the data bus.)

V. **Buffers and how they work**

A. Buffers may be integrated into the microprocessor or they may be part of the system

B. The objective of a buffer is to separate (buffer) parts of a circuit that differ in voltage or current requirements

C. Buffers in a microprocessor convert the small current and voltage signals internal to the MOS chip to the higher level of voltage and current needed for TTL logic

Example: CMOS current often run in picoamps (one million of one millionth of an amp) and TTL current levels may range from .4V to 2.4V

VI. **Microprocessor information flow**

A. Information flows through the microprocessor in one of three ways

1. As an ADDRESS word which originates at the microprocessor and flows to the remaining parts of the system

2. As a DATA word which flows in and out of the microprocessor to and from the system

3. As CONTROL information which flows in and out of the microprocessor

B. In order to start information flow, an instruction word must be sent to the microprocessor via the data line in the data bus

C. The information that makes up the instruction will be a binary word that comes down the system data bus and is deposited in a register that is generally known as the "instruction register"

D. After it has been deposited by the data bus, the instruction word will be held or "latched" into the "instruction decode section" of the microprocessor where it will be decoded with a microcoding technique or a gate decoding technique

INFORMATION SHEET

VII. **Control section decoding techniques**

A. Microcoding is the most common decoding technique and in its simplest form appears as a permanently stored memory that contains information concerning how the various parts of the microprocessor must "set up" to execute the tasks requested by the instruction

(NOTE: This procedure can be compared to a mailbox and its contents, with the instruction being equal to the "number" of the mailbox while the "set up" information is found in the contents of the mailbox.)

B. Microcoding is relatively slow because of "look up" time, but it is a common type of memory circuit and is used often because of its easy to design features

Example: If a design error has occurred, a designer can modify a function quickly, and this becomes very important in getting a new design into the market place in a reasonable length of time

C. Gate decoding is a less commonly used decoding technique because it is complicated; however, it is must faster than microcoding

(NOTE: In gate decoding, each set of instructions has a set of gates, some of which may be common to more than one instruction, but for all common purposes, there appears to be a set of gates for each instruction, so when an instruction appears, it flows through the gates and circuitry to set up the proper sections without delay, and that is why it is faster than the microcoding technique where locations must be looked up before execution can occur.)

D. If an error occurs in gate decoding, the entire section has to be redesigned, so its use is limited, but its high execution speed is preferred for certain applications

VIII. **Other functions of the control section**

A. After an instruction has been decoded (by either decoding technique), the appropriate sections of the microprocessor are set up for execution in conjunction with the timing of the clock circuitry

B. The decoder is just one function of the control section, and timing is another very important control section function

C. Once an instruction has been decoded and registers and buffers have been set up, information can flow into or out of both address and data busses as well as the control lines

D. A typical procedure for loading the accumulator would be:

1. At an appropriate clock cycle, the input buffers would allow information to flow from the system data bus onto the internal data bus of the microprocessor and then into the accumulator

2. Several buffers or busses must be opened to the data word before it can flow through

INFORMATION SHEET

E. A typical procedure for data to flow from the data bus through the program counter to the address bus would require:

1. In order for an 8-bit microprocessor to generate a full 16-bit address, it must accept two 8-bit data words from the data bus
2. The two 8-bit data words have to be placed in sequence in the proper part of the program counter
3. When the 16-bit word is in place, it can be released to the address buffers and finally be sent to the 16 address lines of the address bus

IX. **General functions of registers**

A. Registers are used to temporarily store information, process information, and transfer information simultaneously to other locations within the system

B. A register is a storage location for temporary storage of both data and address words

C. The number of storage locations in a register is directly related to the number of bits in the word to be stored

Example: If a register is to deal with data from an 8-bit microprocessor, then the register will contain 8 storage locations

X. **The ALU and its functions**

A. The objective of using a microprocessor instead of ordinary gating and flip-flop circuitry is to be able to perform arithmetic, logic, and decision operations at a high rate of speed in a coordinated form

B. Virtually all arithmetic, logic, and decision functions reside in one area of the microprocessor, the ALU, which works in conjunction with the accumulator or accumulators (depending on hardware) to accomplish its objectives

C. The ALU not only performs arithmetic and logic and sends the information to the accumulator, it also initiates the output which is responsible for changing the bits or flags in the status register

XI. **Specific registers and their functions**

A. Accumulator — This is a fairly general register that is a source or destination for information

Example: Once information is fed to the ALU from the accumulator, and probably from the internal data bus, the two pieces of information are acted on by the accumulator which performs either arithmetic or logical operations on the two data words, and this results in a single data word which is sent to (accumulated in) the accumulator

INFORMATION SHEET

B. Program counter — This register generates addresses and provides sequencing and also synchronizes sequencing with the clock signal

Example: During the execution of a 3-byte instruction, the program counter must step from one address that contains the instruction to the next two addresses that contain the 16 bits of data that will make up the address, and in addition to that, there are machine cycles that take place between the addressing which require the program counter to either hold its present data or proceed to the next step as is necessary to execute whatever instruction has been decoded

(NOTE: Certain branch and jump instructions may require the program counter to be loaded with a nonsequential address which may move the execution of instructions from one section of memory to an entirely different section of memory in either direction.)

C. Stack pointer — This register keeps track of where things are when stacking in memory occurs, and points the programmer to the location of where information is stacked (stored)

D. Index register — This register performs the task of indexing in one direction or the other through memory to help accomplish a repetitive function and is unique in that when instructed it will add or subtract from its contents by 1, a process that is referred to as incrementing (adding) or decrementing (taking away) from the index register

Example: If you wish to make a table of 100 items, you could address 100 separate memory spaces and store 100 separate pieces of data, but the process would require writing 100 instructions and 100 addresses, and this would require about 300 lines of code, but if an index register is used, information storage can be made by indexing one 8-bit register 100 times and simply looking to see if the contents of the index has reached 100, and this could all be accomplished with one storage instruction, one load of the index register, and would use 10 to 12 code lines versus the 300 needed if the index register were not used

E. Status or flag register — This register contains bits of information that indicate the status of the microprocessor at the end of the last instruction that was executed

XII. **Status bits or flags and their functions**

A. Zero flag — Indicates that the contents of the register that was operated on during the last instruction has gone to zero

(NOTE: Various manufacturers use different types of flags — parity flags, decimal flags, and others — but the ones defined here are almost always found in some form in the popular 8-bit microprocessors.)

INFORMATION SHEET

B. Carry flag — Indicates the presence of an extra bit when some arithmetic or logic instruction produces a binary number that is greater than 8 bits

Example: 8-bit microprocessors can perform arithmetic on only 8-bit words, and sometimes when two 8-bit words are added, it is possible to produce a word that cannot be contained in an 8-bit register, and this is sometimes called the ninth bit of 8-bit arithmetic and is the reason a carry flag is necessary

C. Sign flag — Indicates the positive or negative status of the word that has just been acted on, and if it is a positive word, the most significant bit of the word will be 0, and if it is a negative word, the most significant bit will be 1

Example: The sign flag indicates status by coding the contents of the most significant bit, so if that most significant bit is a 0 you have a positive word, and if the most significant bit is 1 you have a negative word

D. Overflow flag — Indicates the presence of an overflow in signed arithmetic and will go "high" to indicate that a correction is required

Example: In summing two positive 8-bit words, it is very possible that the signed positive words will produce a negative answer because the most significant bit of the 8-bit word has been assigned the task of indicating whether the word is positive or negative and this leaves only 7 bits of the word to perform arithmetic with, and in summing two 7-bit words it is very possible to produce an 8-bit answer, and if the 8-bit answer flows over into the most significant bit, it changes the sign from positive to negative; in other words, two positives have produced a negative and the overflow flag will indicate the status and need for correction

E. Interrupt mask flag — Can be set to prevent an incoming interrupt instruction from executing and perhaps stopping the microprocessor in the middle of a critical timed operation

Example: When a programmer knows that a microprocessor is set up with an interrupt signal and that another critically-timed operation has to be executed, the programmer can "set" the interrupt mask flag to prevent the interrupt signal from coming in until the current operations are completed, and the mask flag can be set to "clear" after the priority operation is completed

XIII. Invisible registers and what they do

A. Those registers inside a microprocessor that cannot be accessed by a programmer with an address are known as invisible registers

(NOTE: Invisible registers are also called transparent registers.)

B. Although invisible registers are not address-accessible, they are necessary for the operation of the system and do their work automatically

INFORMATION SHEET

C. The instruction register that brings instructions to the decoder via the data bus is an invisible register

D. Other invisible registers contain the information that is transferred both from and to the data bus, and these are the registers that permit the smooth flow of information to the internal data bus where it is distributed to other registers inside the microprocessor

E. Depending on the microprocessor, there are a number of specialized invisible registers that move information from one part to another, and in some cases even hold information temporarily so it can be fed into internal parts of the microprocessor at the appropriate time

Example: The "Queue" used with Intel's 8088 microprocessor is used to feed information from the 8-bit bus into the 16-bit registers inside the machine and is actually the heart of the IBM PC and IBM compatible machines

XIV. Busses and what they do

A. The purpose of a bus is to carry multiple signals from one part of a circuit or system to another part in such a way that arrivals of all bits of information are timed to coincide

B. The circuitry in a bus may be one of several forms:

1. A pathway in silicon
2. A printed circuit pathway
3. An ordinary conductor wire

C. Most busses in microcomputers are parallel syncronous busses to indicate the element of timing essential to their functions

(NOTE: Some technical literature refers to any collection of signals as a bus whether they're asyncronous or syncronous, and although the reference is used only to indicate the presence of multiple signals, the signals do not depart or arrive at the same time and the signals may, in fact, not even be similar.)

XV. The clock and clock circuitry

A. Clock circuitry is the timing circuitry for the microprocessor as well as the entire microcomputer system

B. Most microprocessor systems synchronize to one clock, except for some of the newer asynchronous equipment

INFORMATION SHEET

C. The clock is typically in one of two forms:

  1. A complete separate component which may include not only the clock circuitry but the actual timing device such as a crystal

  2. A silicon circuit on board the microprocessor which will have an external timing component such as an R/C network or a crystal

D. Most microprocessors use two nonoverlapping clock signals:

  1. One signal is used for timing addressing

  2. The second signal is used for timing data exchange

XVI. **Stack operations**

A. Operating microcomputer programs sometimes requires that the microprocessor stop what it is currently doing for a short period and complete an interrupt or a subroutine

B. Stopping and starting a program at a specific point is accomplished by saving the location of the program counter or the contents of any register that can change

C. Saving program information is accomplished by stacking that information into memory locations known as stack registers

D. The stack operation always uses memory of some sort to store important information from the microprocessor registers, and then it restores the information to the proper register at the appropriate time

XVII. **Interrupts and how they work**

A. An interrupt is a requesting signal service by the microprocessor from some piece of equipment outside of the hardware

B. An interrupt will cause a microprocessor to stop what it is doing and perform some other operation that has been previously programmed

C. Interrupts permit external asynchronous input into the microprocessor so it can be used for multiple purposes

Example: If a microprocessor is set up to control environmental functions in a home and it is also desired that the microprocessor act as a security system, it would be somewhat impractical to have the microprocessor continually evaluate the status of every window and door, rather, the security function could be tied into the interrupt structure of the microprocessor so that when any door or window is improperly accessed, the microprocessor would stop what it is doing and sound an alarm or alert local law enforcement officials via a phone line

INFORMATION SHEET

XVIII. **I/O devices and their functions**

A. I/O devices are ports or windows that permit the microprocessor to reach the outside world and the means whereby the outside world can reach the microprocessor

B. I/O equipment is designed to allow connection of busses that carry information in the form of data and addresses to the actual equipment and devices outside the microprocessor system

C. Information flows from the busses to the external equipment via the I/O devices and returns from the external equipment to the busses via I/O devices

XIX. **Structured programming and its objectives**

A. Structured programs are those where larger programs are broken into parts or subroutines and then each part or subroutine written as if it were a separate program

B. The smaller subroutines are diagrammed, written, run, and debugged as individual programs, and then the subroutines are integrated into the larger program which is then tested

C. The structured programming concept helps avoid the almost impossible task of debugging long, complicated programs

D. Structured programming is often done in order with the large program broken into modules and then the modules written and tested in order from beginning to end, and this is known as "top down design"

(NOTE: Finding bugs in a large, complex program is time consuming and very expensive, so the structured programming concept or "top down" technique saves time, money, and some terrible headaches.)

XX. **Programming models and their uses**

A. A programming model is used by a programmer to determine what parts of the microprocessor are available or what parts of the microprocessor will be affected by the program

B. A programming model typically is a diagram which shows the registers, flags or status bits, and other features within the microprocessor that can be accessed

INFORMATION SHEET

XXI. **Memory mapping** (Transparency 2)

A. Memory mapping is the process of diagramming available memory within a microprocessor and labeling the line diagram so that all available memory is identified by its starting and ending address

B. Since the typical 8-bit microprocessor has a span of memory from 0 to 65,535 addresses, the map usually starts at address 0 and progresses toward the 65,535 address

C. Many memory maps have blocks of memory that are not contiguous, but even when there are gaps in the memory map, the relationship between the blocks of memory is still accurately shown

XXII. **Machine language programming activities and their functions**

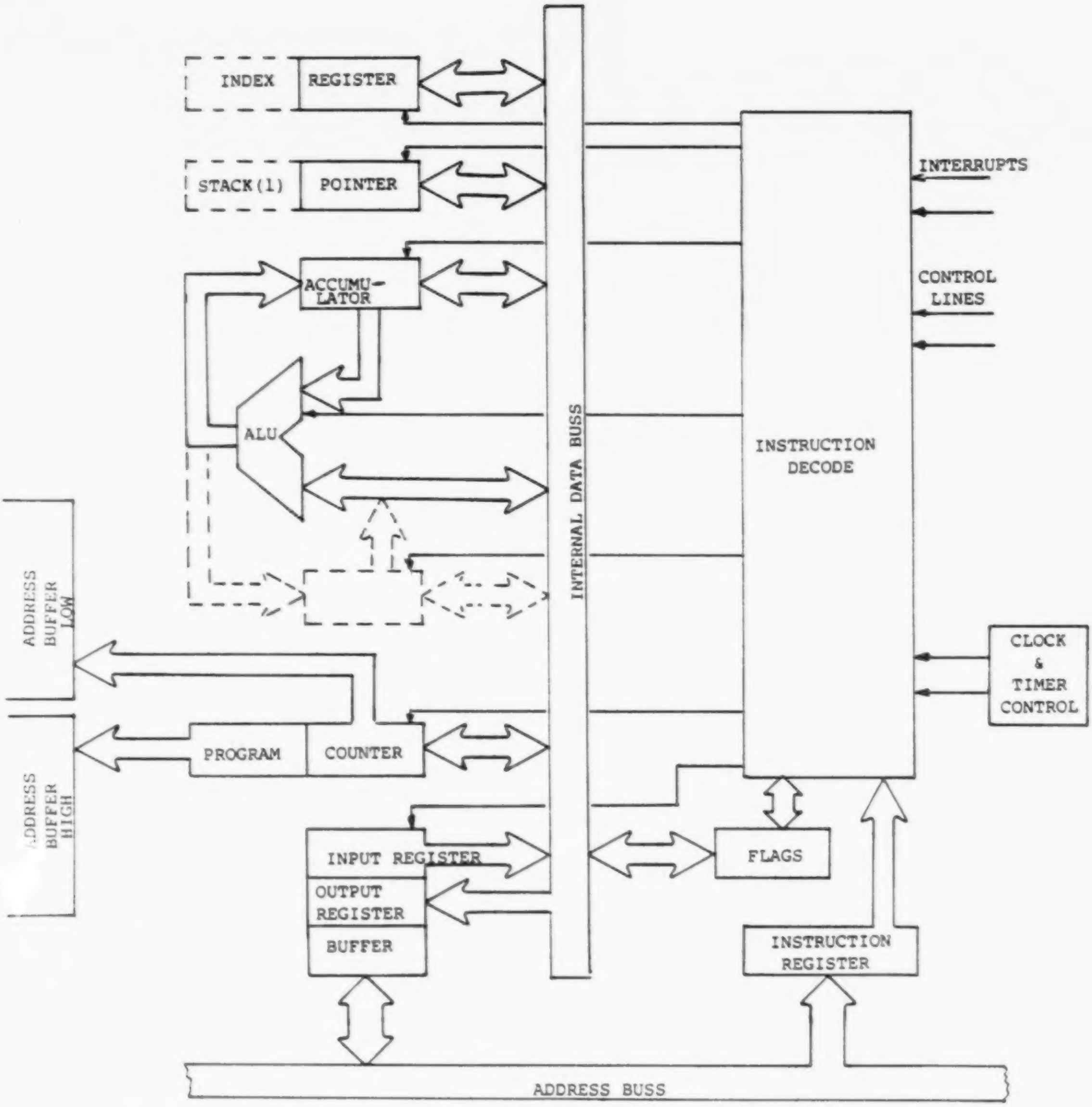
A. Flow chart — A chart developed in conjunction with the writing of a computer program to depict with lines and symbols the direction and interconnection of the code steps in the program (Transparency 3)

B. Debugging — The identification, evaluation, and correction of problems and errors in a computer program

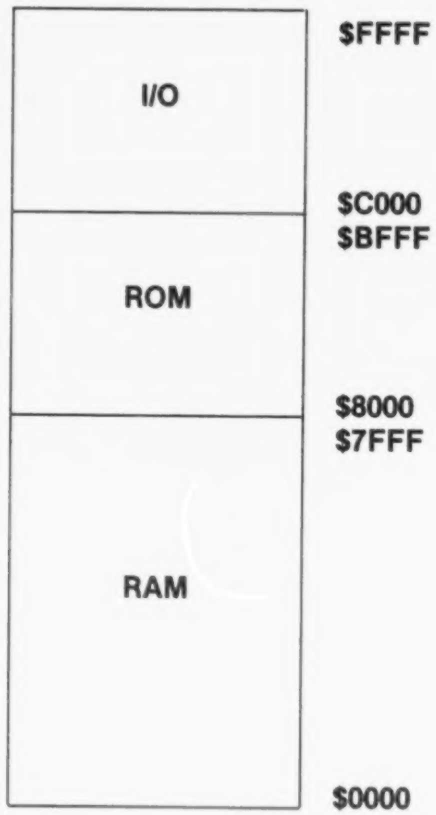
C. Documentation — The written or printed information that supports software with instructions, addresses, data, and descriptions of what is going on at certain steps in a computer program

(NOTE: Although documentation is commonly used with software, it is also used to support some hardware, and programming itself can be a valuable troubleshooting skill.)

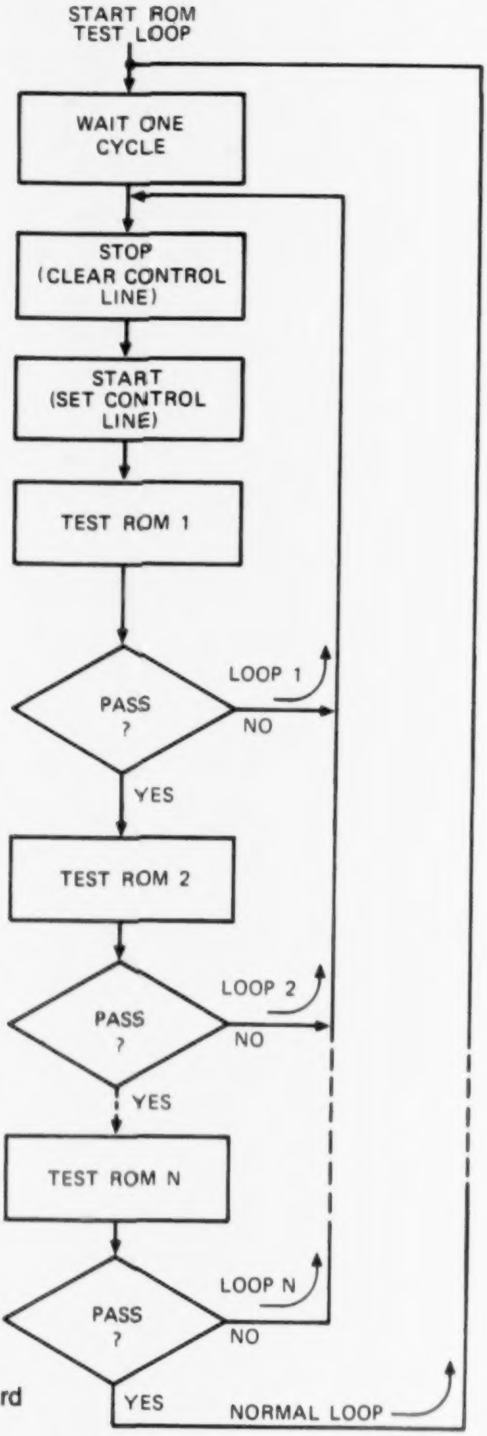
Microprocessor Block Diagram


INDEX
REGISTER
STACK(1)
POINTER
ACCUMULATOR
ALU
INTERNAL DATA BUSS
INSTRUCTION DECODE
INTERRUPTS
CONTROL LINES
CLOCK & TIMER CONTROL
ADDRESS BUFFER LOW
ADDRESS BUFFER HIGH
PROGRAM
COUNTER
INPUT REGISTER
OUTPUT REGISTER
BUFFER
FLAGS
INSTRUCTION REGISTER
ADDRESS BUSS

Memory Map


I/O
ROM
RAM
$FFFF
$C000
$BFFF
$8000
$7FFF
$0000

Loop on Fail Flowchart


START ROM
TEST LOOP
WAIT ONE CYCLE
STOP (CLEAR CONTROL LINE)
START (SET CONTROL LINE)
TEST ROM 1
PASS ?
LOOP 1
NO
YES
TEST ROM 2
PASS ?
LOOP 2
NO
YES
TEST ROM N
PASS ?
LOOP N
NO
YES
NORMAL LOOP

Courtesy Hewlett-Packard

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS CONCERNING MICROPROCESSOR OPERATIONS

Directions: Read the following questions carefully, and use the technical terms required in your answers.

A. When an instruction word is sent down the system data bus in order to start information flow in a microprocessor, where is that instruction word deposited?

Answer ____

____

B. How does an instruction word get into the instruction decode section?

Answer ____

____

C. If you wanted a system capable of decoding at extremely high rates of speed, would you pick a microcoding technique or a gate decoding technique, and what kind of limitations would be involved?

Answer ____

____

D. In what part of the microprocessor are the timing functions located?

Answer ____

____

E. In what part of the microprocessor would a command to multiply be executed?

Answer ____

____

F. Most microprocessors use two nonoverlapping clock signals; why is this necessary?

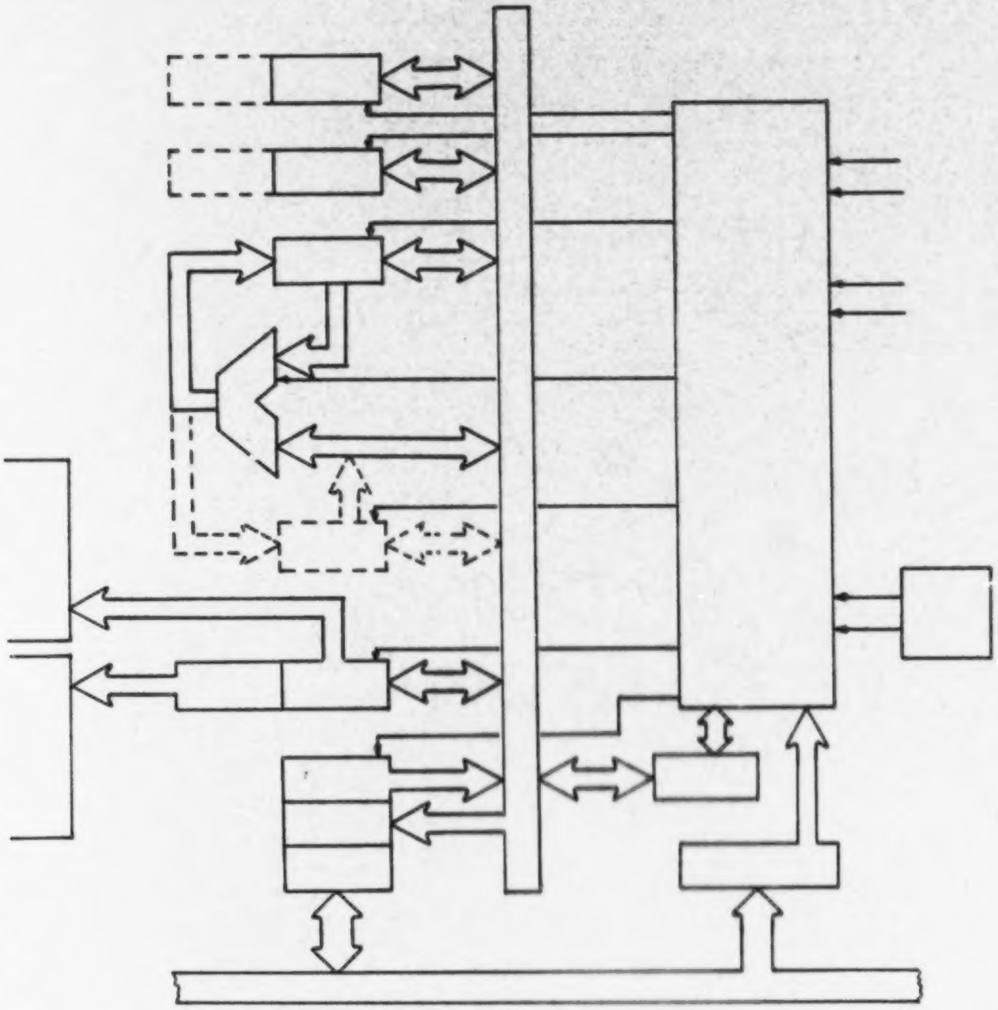
Answer ____

____

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

ASSIGNMENT SHEET #2 — FILL IN A BLOCK DIAGRAM OF A MICROPROCESSOR

Directions: Pay attention to the location of arrows in the following untitled block diagram and insert the names of the sections of a typical microprocessor.



FUNDAMENTALS OF MICROPROCESSORS
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. Instruction register

B. It is latched or held onto the decode section

C. Gate decoding is the fastest, but it is complicated and requires complete redesign of a section if an error occurs

D. The control section

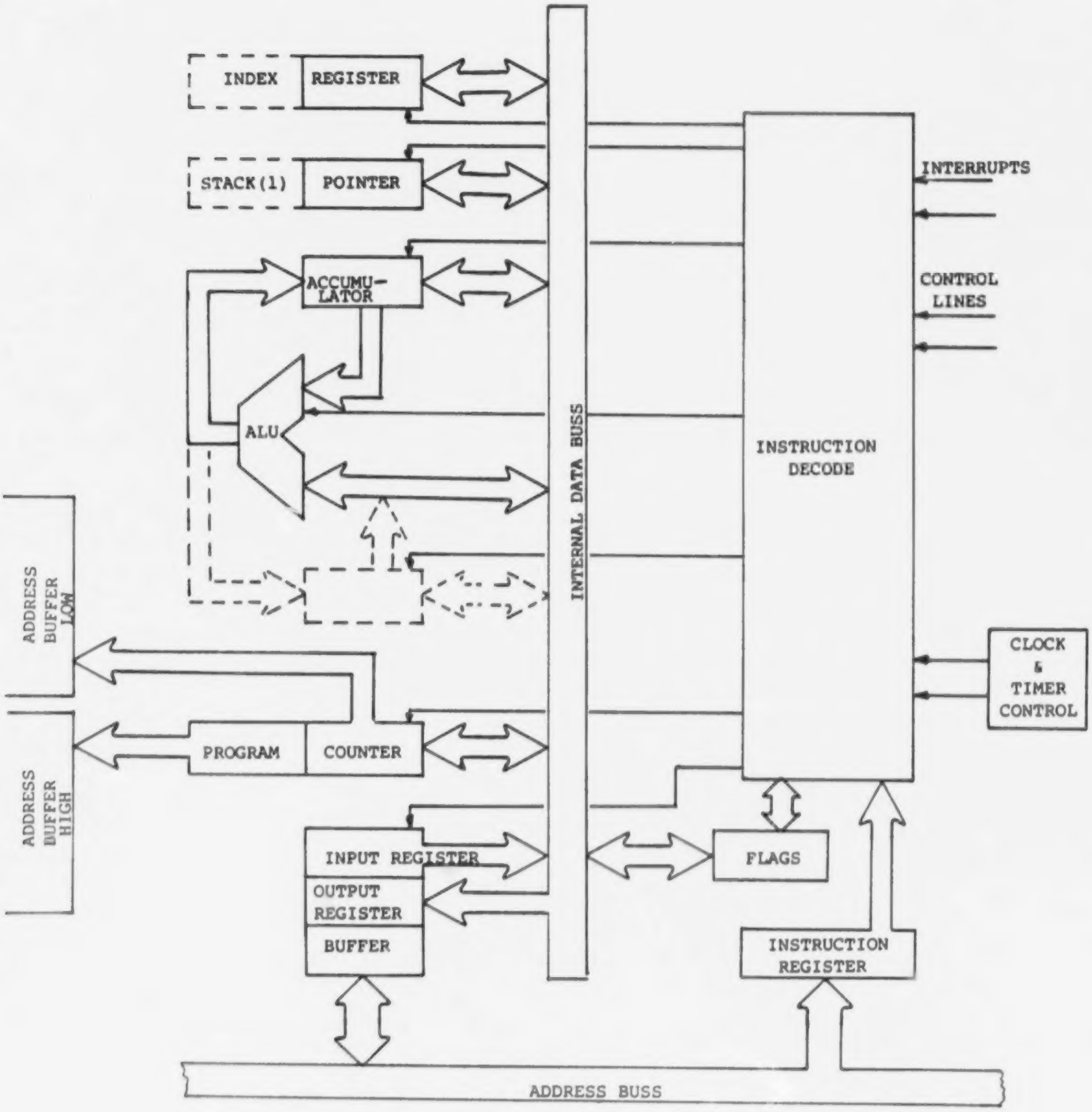
E. The ALU

F. So that the timing for addressing and data exchange will not conflict

(NOTE: See next page for answers to Assignment Sheet #2)

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #2


INDEX
REGISTER
STACK(1)
POINTER
ACCUMU-LATOR
ALU
INTERNAL DATA BUSS
INSTRUCTION DECODE
INTERRUPTS
CONTROL LINES
CLOCK & TIMER CONTROL
ADDRESS BUFFER LOW
ADDRESS BUFFER HIGH
PROGRAM
COUNTER
INPUT REGISTER
OUTPUT REGISTER
BUFFER
FLAGS
INSTRUCTION REGISTER
ADDRESS BUSS

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. A binary word that the microprocessor uses as an address to determine the location of a memory or I/O word

_____b. A binary word that the microprocessor manipulates internally by moving, storing, or operating on the word to obtain a desired result

_____c. An electronic component that is used to precisely time events in a device such as a microprocessor

_____d. Increasing the contents of an address or register by one

_____e. Decreasing the contents of an address or register by one

_____f. An electronic device capable of holding a predetermined electrical condition

_____g. The bit that represents the lowest digit in a binary number or the bit to the far right

_____h. The bit that represents the highest digit in a binary number or the bit to the far left

_____i. The timing of a bit or binary word so that it coincides with a precisely timed signal source

_____j. The condition in which the timing of a bit or binary word does not coincide with the signal source used in the system

_____k. A means of identifying the procedure of placing bits or words of binary information in sequence

1. Latch
2. Queue
3. Incrementing
4. Most significant bit
5. Data word
6. Asynchronous
7. Crystal
8. Decrementing
9. Synchronous
10. Address word
11. Least significant bit

TEST

2. Match electricity/electronics areas with their definitions.

_____a. The study of basic laws, basic circuitry, basic instrumentation, and generally the fundamental principles that underlie electricity and its applications

_____b. The study of electrical controls, the transistors and other devices used in control circuitry, and the operation and troubleshooting of control circuitry as it is used in power supplies, amplifiers, and other control devices

_____c. The relatively new and very different area of electronics that studies the use of nonlinear binary-type signals used in logic and computing circuitry and how these circuits function in microcomputers, microcontrollers, and other control devices

1. Basic electronics
2. Digital electronics
3. Basic electricity

3. Complete the following statements concerning student prerequisites by inserting the word(s) that best completes each statement.

a. Students using this text require basic skills in _____________, _____________, and _____________ electronics

b. Students using this text should also know how to properly use _____________ _____________ and _____________ _____________ needed in the troubleshooting and repair of microcomputer systems

c. Students hoping to succeed as advanced microcomputer repair technicians should already have or should develop superior skills in _____________ and _____________

d. Students of advanced computer repair should review troubleshooting procedure required for basic system service and pay special attention to items concerning _____________ _____________

4. Complete the following statements concerning sections of a microprocessor by inserting the word(s) that best completes each statement.

a. Control section — Contains the _____________ register, the _____________ for decoding instructions, the _____________ circuitry, and the _____________ circuitry

TEST

b. Register section — Contains the ____________ and all the working registers:

1) ____________ counter

2) ____________ registers

3) ____________

4) ____________ pointers

5) Status or ____________ register

5. Select true statements concerning buffers and how they work by placing an "X" in the appropriate blanks.

_____a. Buffers may be integrated into the microprocessor or they may be part of the system

_____b. The objective of a buffer is to separate parts of a circuit that differ in voltage or current requirements

_____c. Buffers in a microprocessor change the small current and voltage signals internal to the MOS chip to the level of TTL logic

6. Solve the following problems concerning microprocessor architecture and information flow.

a. What would happen to information flow in a microprocessor if there were trouble on the data bus?

Solution ____

____

b. If there were a problem with addressing, what part of the system would you suspect and why?

Solution ____

____

7. Solve the following problems concerning decoding techniques and their characteristics.

a. What is the most common decoding technique and what are its two outstanding characteristics?

Solution ____

____

TEST

b. Name a second decoding technique, state why it is less used, and list its outstanding characteristics.

Solution ____

____

8. Complete the following statements concerning other functions of the control section by inserting the word(s) that best completes each statement.

a. After an instruction has been decoded, the appropriate sections of the microprocessor are set up for execution in conjunction with the timing of the ____________ circuitry

b. The decoder is just one function of the control section, and ____________ is another very important control section function

c. Once an instruction has been decoded and registers and buffers have been set up, information can flow ____________ or ____________ ____________ both address and data busses as well as the control lines

d. A typical procedure for loading the accumulator would be:

1) At an appropriate clock cycle, the input buffers would allow information to flow from the system data bus onto the internal data bus of the microprocessor and then into the ____________

2) Several buffers or busses must be opened to the data word before it can ____________ ____________

e. A typical procedure for data to flow from the data bus through the program counter to the address bus would require:

1) In order for an 8-bit microprocessor to generate a full 16-bit address, it must accept ____________ 8-bit data words from the data bus

2) The ____________ 8-bit data words have to be placed in sequence in the proper part of the ____________ ____________

3) When the 16-bit word is in place, it can be released to the address buffers and finally be sent to the ____________ address lines of the address bus

9. Complete the following statements concerning general functions of registers by inserting the word(s) that best completes each statement.

a. Registers are used to temporarily ____________ information, ____________ information, and ____________ information simultaneously to other locations within the system

b. A register is a storage location for temporary storage of both ____________ and ____________ words

c. The number of storage ____________ in a register is directly related to the number of bits in the word to be stored

TEST

10. Complete the following statements concerning the ALU and its functions by inserting the word(s) that best completes each statement.

    a. The objective of using a microprocessor instead of ordinary gating and flipflop circuitry is to be able to perform arithmetic, logic, and decision operations at a ____________ ____________ of speed in a ____________ form

    b. Virtually all arithmetic, logic, and decision functions reside in one area of the microprocessor, the ____________, which works in conjunction with the accumulator or accumulators to accomplish its objectives

    c. The ____________ not only performs arithmetic and logic and sends the information to the accumulator, it also initiates the output which is responsible for changing the bits or ____________ in the ____________ register

11. Match specific registers with their functions.

    _____a. This is a fairly general register that moves information into the ALU, receives information in return, and accumulates an answer

    _____b. This register generates addresses and provides sequencing and also synchronizes sequencing with the clock signal

    _____c. This register keeps track of where things are when stacking in memory occurs, and points the programmer to the location of where information is stacked

    _____d. This register performs the task of indexing in one direction or the other through memory to help accomplish a repetitive function and is unique in that when instructed it will add or subtract from its contents by 1, a process that is referred to as incrementing or decrementing from the index register

    _____e. This register contains bits of information that indicate the status of the microprocessor at the end of the last instruction that was executed

    1. Stack pointer
    2. Status or flag register
    3. Accumulator
    4. Program counter
    5. Index register

TEST

12. Match status bits or flags with their functions.

______a.	Indicates that the contents of the register that was operated on during the last instruction has gone to zero	1. Carry flag 2. Overflow flag
______b.	Indicates the presence of an extra bit when some arithmetic or logic instruction produces a number that is greater than 8 bits	3. Sign flag 4. Interrupt mask flag
______c.	Indicates the positive or negative status of the word that has just been acted on, and if it is a positive word, the most significant bit of the word will be 0, and if it is a negative word, the most significant bit will be 1	5. Zero flag
______d.	Indicates the presence of an overflow in signed arithmetic and will go "high" to indicate that a correction is required	
______e.	Can be set to prevent an incoming interrupt instruction from executing and perhaps stopping the microprocessor in the middle of a critical timed operation	

13. Complete the following statements concerning invisible registers and what they do by inserting the word(s) that best completes each statement.

a. Those registers inside a microprocessor that cannot be accessed by a programmer with an ____________ are known as invisible registers

b. Although invisible registers are not address-accessible, they are necessary for the operation of the system and do their work ____________

c. The ____________ register that brings instructions to the decoder via the data bus is an invisible register

d. Other invisible registers contain the information that is transferred both from and to the ____________ ____________ and these are the registers that permit the smooth flow of information to the internal data bus where it is distributed to other registers inside the microprocessor

e. Depending on the microprocessor, there are a number of specialized invisible registers that ____________ information from one part to another, and in some cases even ____________ information temporarily so it can be fed into internal parts of the microprocessor at the appropriate time

TEST

14. Complete the following statements concerning busses and what they do by inserting the word(s) that best completes each statement.

    a. The purpose of a bus is to carry ____________ signals from one part of a circuit or system to another part in such a way that arrivals of bits of information are timed to coincide

    b. The circuitry in a bus may be one of several forms:

        1) A ____________ in silicon

        2) A ____________ ____________ pathway

        3) An ordinary ____________ ____________

    c. Most busses in microcomputers are ____________ ____________ busses to indicate the element of timing essential to their functions

15. Solve the following problems concerning the clock and clock circuitry.

    a. A schematic indicates a system has the clock on board the microprocessor, so will there be any kind of external component involved?

       Solution ____

       ____

    b. An oscilloscope test shows clock signals overlapping one another, so what will happen to addressing and data exchange?

       Solution ____

       ____

16. Complete the following statements concerning stack operations by inserting the word(s) that best completes each statement.

    a. Operating microcomputer programs sometimes requires that the microprocessor stop what it is currently doing for a short period and complete an ____________ or a ____________

    b. Stopping and starting a program at a specific point is accomplished by saving the location of the ____________ ____________, and in some cases, the specific contents of memory registers

    c. Saving program information is accomplished by ____________ that information into memory locations known as ____________ registers

    d. The ____________ operation always uses memory of some sort to ____________ important information from the microprocessor registers, and then it ____________ the information to the proper register at the appropriate time

TEST

17. Complete the following statements concerning interrupts and how they work by inserting the word(s) that best completes each statement.

    a. An interrupt is a special signal received by the microprocessor from some piece of equipment ____________ of the hardware contained in the system

    b. An interrupt will cause a microprocessor to stop what it is doing and perform some other operation that has been ____________ ____________

    c. Interrupts permit external ____________ input into the microprocessor so it can be used for multiple purposes

18. Complete the following statements concerning I/O devices and their functions by inserting the word(s) that best completes each statement.

    a. I/O devices are ports or windows that permit the microprocessor to reach the ____________ ____________ and the means whereby the ____________ ____________ can reach the microprocessor

    b. I/O equipment is designed to allow connection of ____________ that carry information in the form of data and addresses to the actual equipment and devices outside the microprocessor system

    c. Information flows from the ____________ to the external equipment via the I/O devices and returns from the external equipment to the ____________ via I/O devices

19. Solve the following problems concerning structured programming and its objectives.

    a. What is the major programming burden that structured programming alleviates and how is this objective accomplished?

       Solution ____

       ____

    b. Since structured programming is a design concept, is there another name for it?

       Solution ____

       ____

20. Complete the following statements concerning programming models and their uses by inserting the word(s) that best completes each statement.

    a. A programming model is used by a programmer to determine what parts of the microprocessor are ____________ or what parts of the microprocessor will be ____________ by the program

    b. A programming model typically is a ____________ which shows the registers, flags or status bits, and other features within the microprocessor that can be accessed

TEST

21. Complete the following statements concerning memory mapping by inserting the word(s) that best completes each statement.

    a. Memory mapping is the process of diagramming available memory within a microprocessor and so labeling the line diagram that all available memory is identified by its ____________ and ____________ address

    b. Since the typical 8-bit microprocessor has a span of memory from 0 to 65,535 addresses, the map usually starts at address ____________ and progresses toward the 65,535 address

    c. Many memory maps have blocks of memory that are not contiguous, but even when there are gaps in the memory map, the ____________ between the blocks of memory is still accurately shown

22. Match programming activities with their functions.

_____a.	A chart developed in conjunction with the writing of a computer program to depict with lines and symbols the direction and interconnection of the code steps in the program	1. Flow chart 2. Debugging 3. Documentation
_____b.	The identification, evaluation, and correction of problems and errors in a computer program	
_____c.	The written or printed information that supports software with instructions, addresses, data, and descriptions of what is going on at certain steps in a computer program	

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

23. Solve problems concerning microprocessor operations. (Assignment Sheet #1)

24. Fill in a block diagram of a microprocessor. (Assignment Sheet #2)

FUNDAMENTALS OF MICROPROCESSORS
UNIT I

ANSWERS TO TEST

1.
   a. 10
   b. 5
   c. 7
   d. 3
   e. 8
   f. 1
   g. 11
   h. 4
   i. 9
   j. 6
   k. 2

2.
   a. 3
   b. 1
   c. 2

3.
   a. Electricity, electronics, digital
   b. Hand tools, test equipment
   c. Desoldering, soldering
   d. Record keeping

4.
   a. Input, decoder, timing, interrupt
   b. ALU
      1) Program
      2) Index
      3) Accumulators
      4) Stack
      5) Flag

5. a,b,c

6.
   a. Information flow is carried on data line out of the data bus to the microprocessor, so there would be no information flow if there were trouble on the data bus
   b. Since addressing originates at the microprocessor, the problem would probably be there

7.
   a. Microcoding is the most common decoding technique because it is easy to design, but is relatively slow because of "look up" time
   b. Gate decoding is the second decoding technique used less because it is complicated, but much faster than microcoding

8.
   a. Clock
   b. Timing
   c. Into, out of
   d.
      1) Accumulator
      2) Flow through
   e.
      1) Two
      2) Two, program counter
      3) 16

9.
   a. Store, process, transfer
   b. Data, address
   c. Locations

ANSWERS TO TEST

10. a. High rate, coordinated
    b. ALU
    c. ALU, flags, status

11. a. 3
    b. 4
    c. 1
    d. 5
    e. 2

12. a. 5
    b. 1
    c. 3
    d. 2
    e. 4

13. a. Address
    b. Automatically
    c. Instruction
    d. Data bus
    e. Move, hold

14. a. Multiple
    b. 1) Pathway
       2) Printed circuit
       3) Conductor wire
    c. Parallel synchronous

15. a. Yes, usually an R/C network or a crystal
    b. One or both will be out of time

16. a. Interrupt, subroutine
    b. Program counter
    c. Stacking, stack
    d. Stack, store, restores

17. a. Outside
    b. Previously programmed
    c. Asynchronous

18. a. Outside world, outside world
    b. Busses
    c. Busses, busses

19. a. The major burden is debugging, and shorter subroutines make this easier
    b. Top down design

ANSWERS TO TEST

20. a. Available, affected
    b. Diagram

21. a. Starting, ending
    b. 0
    c. Relationship

22. a. 1
    b. 2
    c. 3

23.-24. Evaluated to the satisfaction of the instructor

SYSTEM ARCHITECTURE
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the architecture of microcomputer systems and relate system parts such as the microprocessor, busses, and memories to the overall operations of a microcomputer system. The student should also be able to define clock and timing functions. These competencies will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to system architecture with their correct definitions.
2. Select true statements concerning memory mapping.
3. Complete statements concerning the importance of microprocessor control functions.
4. List the busses on a typical microcomputer.
5. Complete statements concerning characteristics of the data bus.
6. Complete statements concerning characteristics of the address bus.
7. Complete statements concerning characteristics of the control bus.
8. Complete statements concerning characteristics of the system bus.
9. Select true statements concerning busses and I/O relationships.
10. Complete statements concerning ROM's and their characteristics.

OBJECTIVE SHEET

11. Complete statements concerning read/write memories (RAM's) and their characteristics.
12. Select true statements concerning timing circuits.
13. Complete statements concerning clock signals.
14. Complete statements concerning clock phases.
15. Complete statements concerning other timing signals.
16. Solve problems related to system architecture and bus activity. (Assignment Sheet #1)
17. Diagram the relationship between the microprocessor and other system components in typical system architecture. (Assignment Sheet #2)

SYSTEM ARCHITECTURE
UNIT II

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and assignment sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheet.

F. Use TM 1 effectively to show both bus structure and information flow within system architecture, and impress upon students the need to know system architecture in order to troubleshoot system malfunctions.

G. Demonstrate with an oscilloscope the nonoverlapping timing signals out of one of the popular microprocessors, and also use a schematic or pictorial to show how the oscilloscope display differs from graphic representations.

H. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Transparency masters

  1. TM 1 — Expanded Memory Map

  2. TM 2 — System Architecture

D. Assignment sheets

  1. Assignment Sheet #1 — Solve Problems Related to System Architecture and Bus Activity

  2. Assignment Sheet #2 — Diagram the Relationship Between the Microprocessor and Other System Components in Typical System Architecture

E. Answers to assignment sheets

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Stephenson, John, and Bob Cahill. *How to Maintain and Service Your Small Computer.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1983.

B. Drischoll, Frederick F. *Microprocessor-Microcomputer Technology.* North Scituate, MA 02060: Breton Publishers, a division of Wadsworth, Inc., 1983.

C. Tocci, Ronald J., and Lester P. Laskowski. *Microprocessors and Microcomputers.* Englewood Cliffs, NJ 07632: Prentice-Hall, Inc., 1979.

D. *Sams Computerfacts™ CC5, COMPUTER: Atari 400™.* Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1984.

E. *Component Data Catalog.* Santa Clara, CA 95051: Intel Corporation, 1982.

SYSTEM ARCHITECTURE
UNIT II

INFORMATION SHEET

I. **Terms and definitions**

A. Compatibility — The capacity of a device to function effectively with another device or within a system

B. IEEE — Institute of Electrical and Electronics Engineers

C. Interrupt — The temporary suspension of microcomputer activity in response to a priority command from another part of the system

D. Nonvolatile — A way of describing memory devices that retain information stored in them whether power is on or off

E. ϕ — The symbol for "phase" used on schematics to indicate a time relationship between two electrical waveforms

F. Volatile — A way of describing memory devices that lose information stored in them when power is turned off

II. **Memory mapping**

A. In a typical 8-bit microprocessor, memory is addressed by the address bus, and the different kinds of memory are usually grouped together so that RAM, ROM, and I/O addresses will be easy to find

B. Memory mapping is a handy way of showing where the hex addresses begin and end for each type of memory, and the map is often a block diagram designed to help a programmer or troubleshooter better visualize memory locations (Transparency 1)

C. A memory map for a typical 8-bit microprocessor will have RAM from hex locations $0000 to $7FFF, ROM from $8000 to $BFFF, and then I/O memory from $C000 to $FFFF

D. It is also common for memory areas to appear to overlap when certain blocks of memory can be shifted for an alternate use by the addressing hardware

Example: After information taken from a floppy disk and placed in RAM is used, a program usually needs more information, so additional information is taken from the disk and placed into RAM so that it overlays the previous information in RAM; and in this way, 64K of memory can ultimately use all the information on a 320K floppy disk program

INFORMATION SHEET

E. When a system can send information out on the data bus to a peripheral or receive information from a peripheral via the data bus, it is said to be ported, and a memory mapped I/O port would usually have hex addresses following RAM and ROM

III. **Importance of microprocessor control functions** (Transparency 2)

A. The microprocessor is the nerve center that controls system operation, but the microprocessor in turn is controlled by software instructions that come in on the data bus:

1. Software instructions can come from ROM to boot the system up

2. Software instructions can come from RAM when the program has been written and stored in RAM

3. Software instructions can also be brought from the keyboard or some other peripheral device and then stored in memory

B. Functions of the data and control busses are separate and unique:

1. All data and instructions flow on the data bus

2. All memory control is initiated by the microprocessor's addressing capability, and address information is usually sent to the system on the address bus

3. All movement of data and instructions and all addressing is synchronized in time by the system clock

C. Knowing the instruction sets and addressing modes for a given microprocessor is essential for programming, but learning all the particulars is not necessary when a language such as BASIC is used

D. When troubleshooting at the hardware level it is sometimes impossible to get a high level language to run the system, and a troubleshooter is sometimes called on to use machine language to use the microprocessor directly

IV. **Busses on a typical microcomputer**

A. The components of a microcomputer system used for carrying signals to and from the microprocessor and to and from other parts of the system are known as busses

INFORMATION SHEET

B. The four busses found on the typical microcomputer are:

1. Data bus
2. Address bus
3. Control bus
4. System bus

   (NOTE: The system bus includes the data, address, and control busses.)

V. **Characteristics of the data bus**

A. May be on a cable or PC board and consists of 8 parallel lines that simultaneously carry 8 binary 1's or 0's or combinations of the two

B. The data bus carries information in 8-bit binary words to and from the microprocessor only

C. The 8-bit binary word is synchronized by the system clock and since it can carry information to or from the microprocessor, it is bidirectional

D. The binary word may contain an instruction, data, or address information because all three types of information are required at various times for the microprocessor to perform computing tasks

VI. **Characteristics of the address bus**

A. May be on a cable or PC board and consists of 16 parallel lines that simultaneously carry 16 binary 1's or 0's or combinations of the two

B. The address bus carries addresses generated by the microprocessor out from the microprocessor to some designated physical device such as RAM, ROM, or I/O

C. Information carried on the address bus may also identify a specific location within RAM, ROM, or I/O that the microprocessor may receive information from as well as send information to

VII. **Characteristics of the control bus**

A. The control bus deals with timing and direction of information

B. The types of signals carried on the control bus normally include:

1. Clock phases
2. Read/write signals
3. Interrupt signals

INFORMATION SHEET

C. Specialized control bus functions vary from system to system, but in all cases, control signals are individual and are not sent in sync along parallel lines as the data and address signals are

VIII. **Characteristics of the system bus**

A. The system bus frequently has slots where cards can be added to the system bus to provide enhanced system operations

B. Expansion and interface boards and cards used to modify or enhance a system must be able to communicate with the system bus, and such boards are termed "compatible"

C. System busses are unique to specific microcomputers, and some system busses such as the S-100 and the SBC multibus have been standardized by the IEEE

D. Other system busses such as the Apple bus and the IBM bus have not been officially standardized, but they are so popular that some of them are "defacto" standardized busses

IX. **Busses and I/O relationships**

A. In some early systems, communications with I/O devices was accomplished with "parallel bus latching," latching devices that latched information from the data bus to an outside peripheral or from an outside peripheral to the data bus

B. The very earliest or peripheral chip I/O devices usually contained two ports that could carry 8 bits of data in either direction and could be controlled by data bits sent to the I/O devices on a control cycle

C. The two-port structure permitted one parallel 8-bit port to be used as an output from the data bus and the other 8-bit port to be used as an input to the data bus, and all controlled by information sent to the peripheral device along the data bus

D. Since some sort of address capability is required to map an I/O device into memory, this took the form of "chip select lines" on the I/O which in turn were connected through decoders to the address lines

E. Chip select lines made it possible for an I/O device to be addressed as if it were memory for sending and receiving information in the form of parallel binary words and also for sending and receiving control signals to set up I/O devices

(NOTE: This was usually accomplished by memory mapping the registers that control I/O functions within a cluster of addresses.)

INFORMATION SHEET

F. As systems became more sophisticated, it became obvious that not only parallel communications with a bus were needed, but also serial communications so information could be sent a bit at a time on a two wire system

(NOTE: Sending a bit at a time is obviously slower than sending 8 bits at a time, but serial communications has the advantages of requiring fewer wires and serial signals can reach greater distances without noise interference.)

G. As systems became more sophisticated, auxiliary functions were placed into I/O ports so the microprocessor would be freed of the time-consuming task of timing auxiliary operations

(NOTE: I/O devices at this sophisticated level have internal control registers and internal status registers to allow the I/O device to operate independently but in sync with the microprocessor.)

H. To further allow I/O devices to operate independently and report efficiently to the microprocessor, most of these I/O devices can generate interrupts to inform the microprocessor that a task is finished and then send and receive information to set up the next task

(NOTE: Improved I/O design frees the microprocessor to continue with other aspects of a program without having to monitor the I/O function or having to wait for the I/O device to complete a function.)

X. **ROM's and their characteristics**

A. ROM sets up initial control in the microcomputer system and performs other decoding operations such as reading the keyboard, controlling information transfer to and from disk or tape, and controlling video display information

B. Because ROM is essential to control operations it must be nonvolatile; it has to there whether power is on or off

C. The type of ROM most commonly used is masked ROM which means that the original pattern of binary words necessary for control functions was placed permanently into the chip as it was manufactured by the OEM or by a specialty silicon foundry

D. Because of the design costs involved and the need to make a part cost effective, it was previously almost impossible for an end user to design nonvolatile ROM

(NOTE: An early type of nonvolatile ROM known as fusible ROM was used in some microomputers and could be easily reproduced with even home made equipment, but the process was tedious and the low density ROM it produced was not suited to large memory chip configuration.)

INFORMATION SHEET

E. Advances in chip technology have produced a type of nonvolatile memory that can be programmed by the end user and these are erasable programmable read only memories or EPROM's

F. EPROM's can be purchased for almost any microcomputer system and consists of a printed circuit card with a programming voltage supply and a special socket to house the EPROM

G. Programs to be placed into EPROM's are usually written, stored in RAM, and then checked by running the program on the microcomputer

H. Even if a mistake is made in programming an EPROM, it can be erased by exposing it to ultraviolet light for approximately half an hour

(NOTE: Most EPROM's can be erased dozens of times and used again, but they cannot be erased and reused indefinitely.)

I. Some EPROM's can be erased electrically and can actually be erased selectively by words or blocks, but because of their low speed and high cost they are not frequently used

(NOTE: Electrically erasable EPROM's have the special identification of E^{2}PROM or EEPROM.)

XI. **Read/write memories (RAM's) and their characteristics**

A. For the purpose of troubleshooting and repair, the only concern is whether a RAM is static or dynamic

B. A static RAM is basically a flip/flop made of silicon while a dynamic RAM is an FET (field effect transistor) where binary 1's and 0's are stored in the capacitance of the FET device

C. A static RAM will hold its binary information pattern as long as power is maintained on the RAM or until changed by a control signal

D. A dynamic RAM will hold a signal charge for about 1 to 2 milliseconds and then the memory must be refreshed in less time than the time required for the memory to be discharged

(NOTE: Capacitors are known for their ability to charge to a voltage and to hold that voltage until discharged, so the capacitance in an FET works the same and after it is charged with a binary signal it can be discharged by normal leakage in the transistor, so this accounts for the need for a refresh cycle.)

INFORMATION SHEET

E. The nature of static and dynamic RAM's affect troubleshooting in this fashion:

1. In static RAM's, problems occur in only the addressing and read/write functions

2. In dynamic RAM's, problems occur not only in the addressing and read/write functions, but also with the refresh functions

F. Since a dynamic RAM cell requires only a fraction of the space required by a static RAM cell, the movement in RAM design is toward the high density dynamic RAM

G. The ability to place large blocks of dynamic RAM on a single chip has made it easier to troubleshoot memory systems, and some dynamic RAM blocks even have a decoding function on the chip which further simplifies the entire system

H. The movement from 1K memories to 16K, 64K, and the trend toward the 256K, 512K, and even greater memory capacity will actually lead to fewer components required to achieve maximum addressable memory and fewer problems for the troubleshooter

XII. **Timing circuits**

A. The timing circuits which control clocking activities may be built into the microprocessor itself or may be located on a part external to the microprocessor

Example: Microprocessors such as the 8085, the 6802, and the 6502 have internal clocks, and microprocessors such as the 8080 and 6800 have external clocks

B. Whether clock circuitry is on board or external, it must produce electrical signals appropriate to the decoding and execution of signals within the microprocessor

C. Whether on board or external, clock signals operate at the TTL level

D. A knowledge of all clocking functions is required for good troubleshooting, but the only clocks that troubleshooters have access to are the external clocks

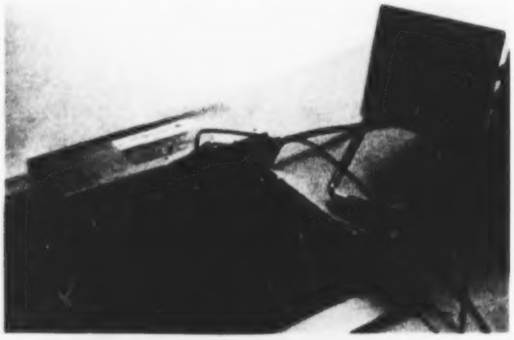
(NOTE: Much of the following information is dedicated to external clock circuitry since they are the only clocks a troubleshooter may be required to replace; trouble in an on board clock would require replacing the entire microprocessor.)

INFORMATION SHEET

XIII. Clock signals

A. Clock signals are recognizable by the waveform shapes they make on an oscilloscope, and these shapes are usually rectangular (Figure 1)

FIGURE 1



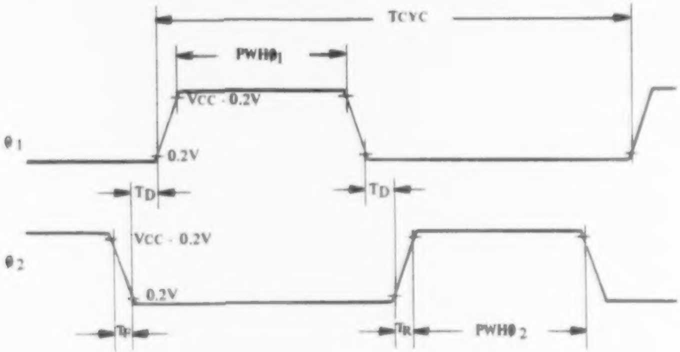
B. Waveforms "pulse" at a rate determined by an external component or network and crystals are most commonly used for this pulsing activity because of their low frequency drift characteristics

C. The most common arrangement for clock signals is to have two signals that go positive at alternate times so that positive time segments do not overlap (Figure 2)

D. Because common clock signals contain two alternating signals, they are referred to as "two-phase nonoverlapping clocks" (Figure 2)

E. The purpose for having two signals timing functions within the system is to assure that the two basic functions of memory addressing and data transfer will not take place at the same time (Figure 2)

FIGURE 2



Courtesy Commodore Business Machines, Inc.

INFORMATION SHEET

XIV. Clock phases

A. Clocking signals are referenced according to their functions as either:

1. $\phi 1$ (phase one)

2. $\phi 2$ (phase two)

B. $\phi 1$ activity is concerned only with addressing

Example: The microprocessor's memory must be addressed before that address can be sent out along the bus to find a given location

C. $\phi 1$ activity is normally used only by the microprocessor because if any other component had control of the $\phi 1$ clock it would interfere with addressing activity

D. $\phi 2$ activity is concerned with transfer of data within the system

Example: Once a location in memory has been addressed, the $\phi 2$ clock times the transfer of data onto the data bus or, if required, from the data bus into memory if data is coming from the microprocessor

XV. Other timing signals

A. Almost all microcomputer systems require more than timing signals for $\phi 1$ addressing and for $\phi 2$ data transfer

B. Timing signals are required for reading and writing to and from memory and other system parts such as I/O components

C. In addition to clock and read/write signals, some systems require special timing signals that may only be associated with a particular microprocessor

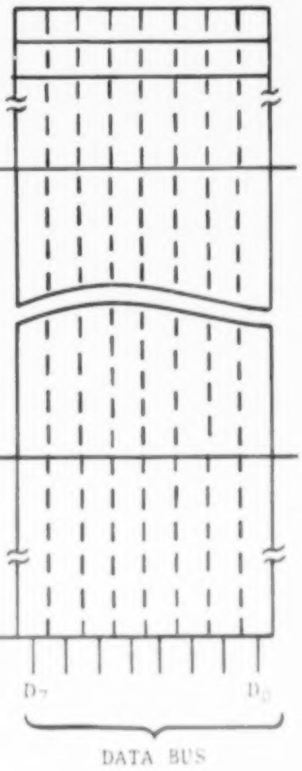
Example: The ALE (address latch enable) associated with the 8080/8085 is used to latch the addresses out on the address line so those address lines may also be cleared for use as data lines

Expanded Memory Map

BINARY ADDRESS				DECIMAL WORD NUMBER	HEXADECIMAL Address Code		
High Order		Low Order					
15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0		Page Number		Byte Number
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	00	-	00
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	1	00	-	01
0 0 0 0	0 0 0 0	1 1 1 1	1 1 1 1	255	00	-	FF
0 0 0 0	0 0 0 1	0 0 0 0	0 0 0 0	256	01	-	00
1 1 1 1	1 1 1 0	1 1 1 1	1 1 1 1	65279	FE	-	FF
1 1 1 1	1 1 1 1	0 0 0 0	0 0 0 0	65280	FF	-	00
1 1 1 1	1 1 1 1	0 0 0 0	0 0 0 1	65281	FF	-	01
1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	65535	FF	-	FF

ADDRESSABLE MEMORY FIELD

(65536 Bytes)

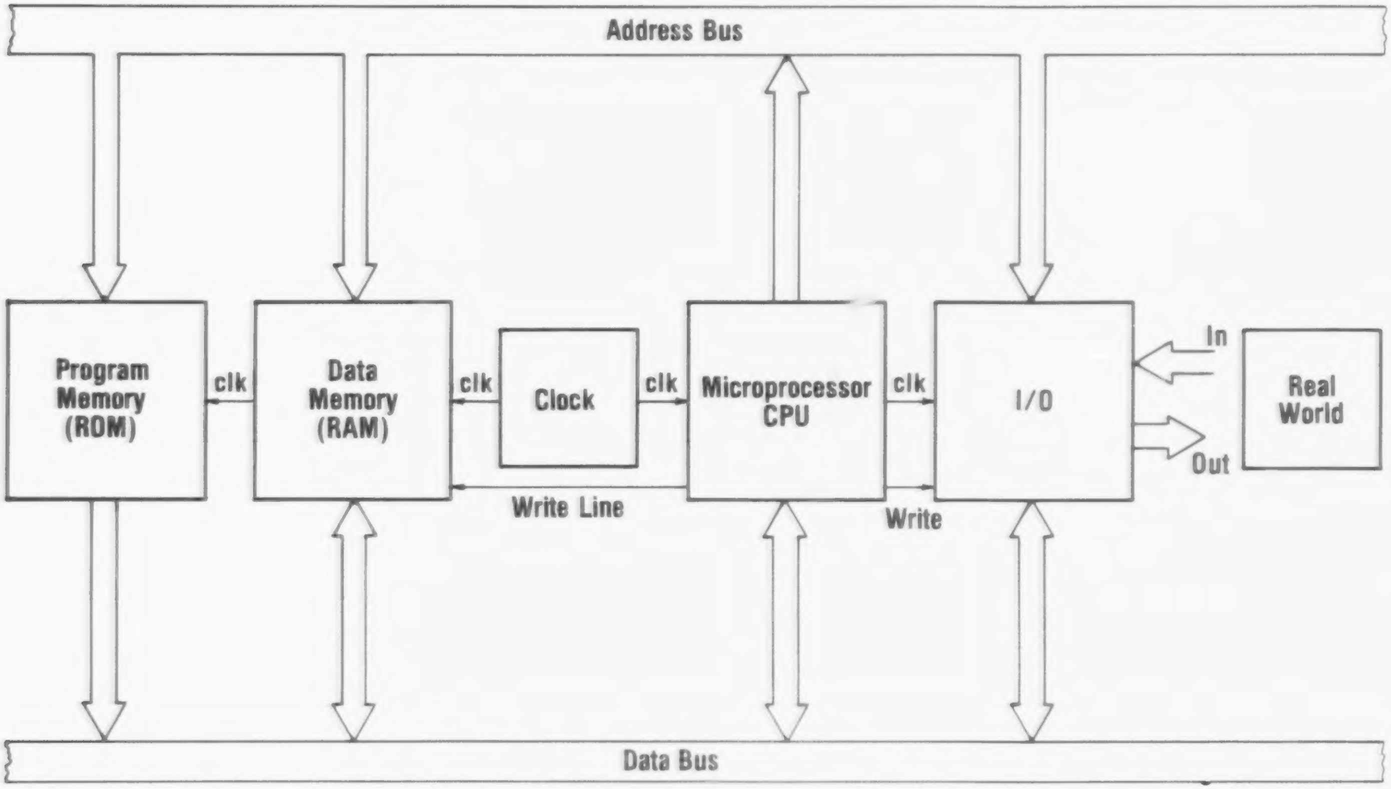


Courtesy Commodore Business Machines, Inc.

TM 1

AMST-57

System Architecture


Address Bus
Program Memory (ROM)
clk
Data Memory (RAM)
clk
Clock
clk
Microprocessor CPU
clk
I/O
In
Out
Real World
Write Line
Write
Data Bus

83

84

SYSTEM ARCHITECTURE
UNIT II

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS RELATED TO SYSTEM ARCHITECTURE AND BUS ACTIVITY

A. What bus carries information to and from the microprocessor only?

Answer ____

B. What bus carries information from the microprocessor to some other component in the system?

Answer ____

C. Timing functions are controlled by what bus?

Answer ____

D. What are the components of a system bus?

Answer ____

E. Are control bus signals normally synchronized?

Answer ____

F. On what bus would interrupt signals appear?

Answer ____

G. Since the data bus can carry information both to and from the microprocessor, how is this capability described?

Answer ____

SYSTEM ARCHITECTURE
UNIT II

ASSIGNMENT SHEET #2 — DIAGRAM THE RELATIONSHIP BETWEEN THE MICROPROCESSOR AND OTHER SYSTEM COMPONENTS IN TYPICAL SYSTEM ARCHITECTURE

Directions: Study the accompanying block diagram carefully, and then insert names from the following list as they are required to reflect typical system architecture. Take your time because there are more names in the list than are needed to complete the diagram.

A. Program memory ROM

B. Control bus

C. Input/Output or I/O

D. System bus

E. Clock

F. Data memory RAM

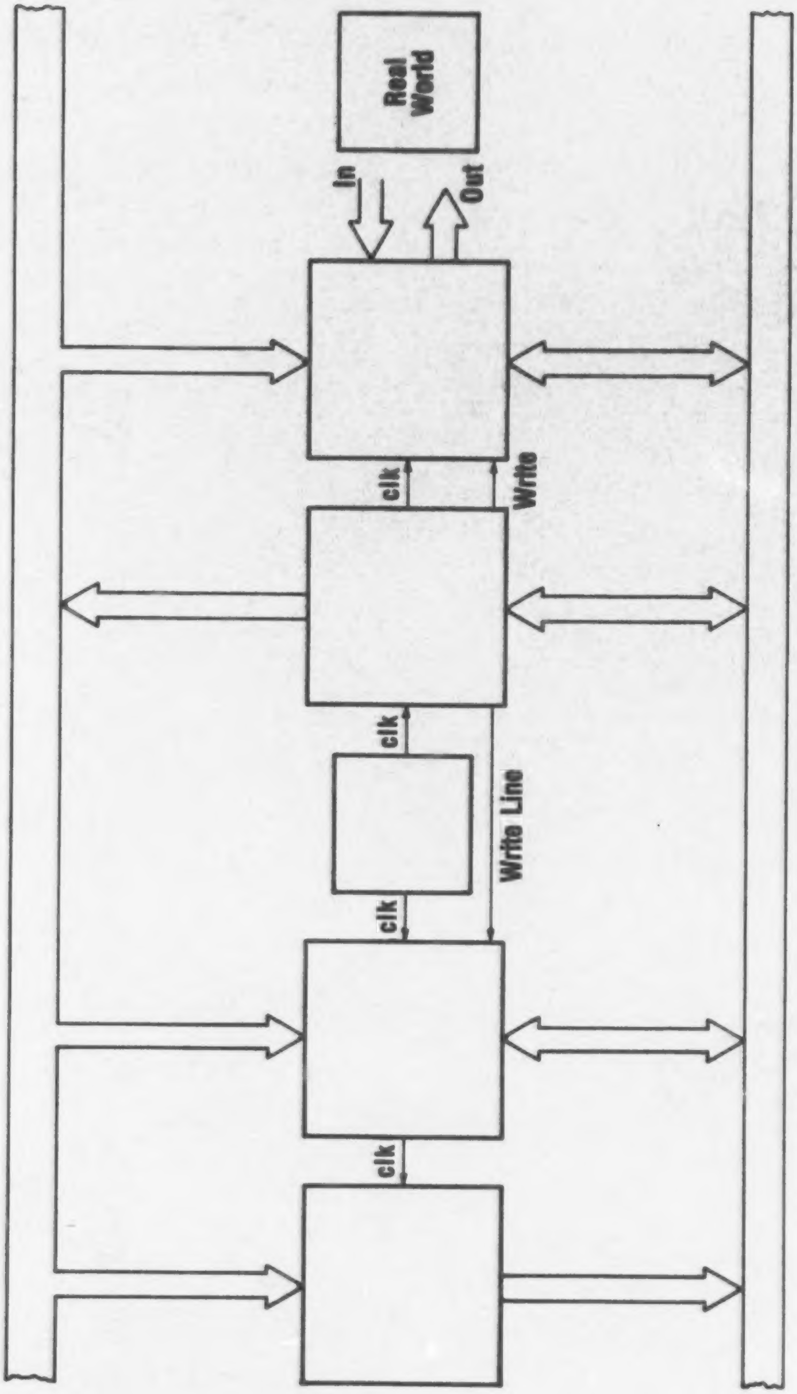
G. Instruction register

H. Microprocessor or MPU or CPU

I. Address bus

J. Data bus

ASSIGNMENT SHEET #2


Real World
In
Out
clk
Write
clk
Write Line
clk
clk

SYSTEM ARCHITECTURE
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. The data bus

B. The address bus

C. The control bus

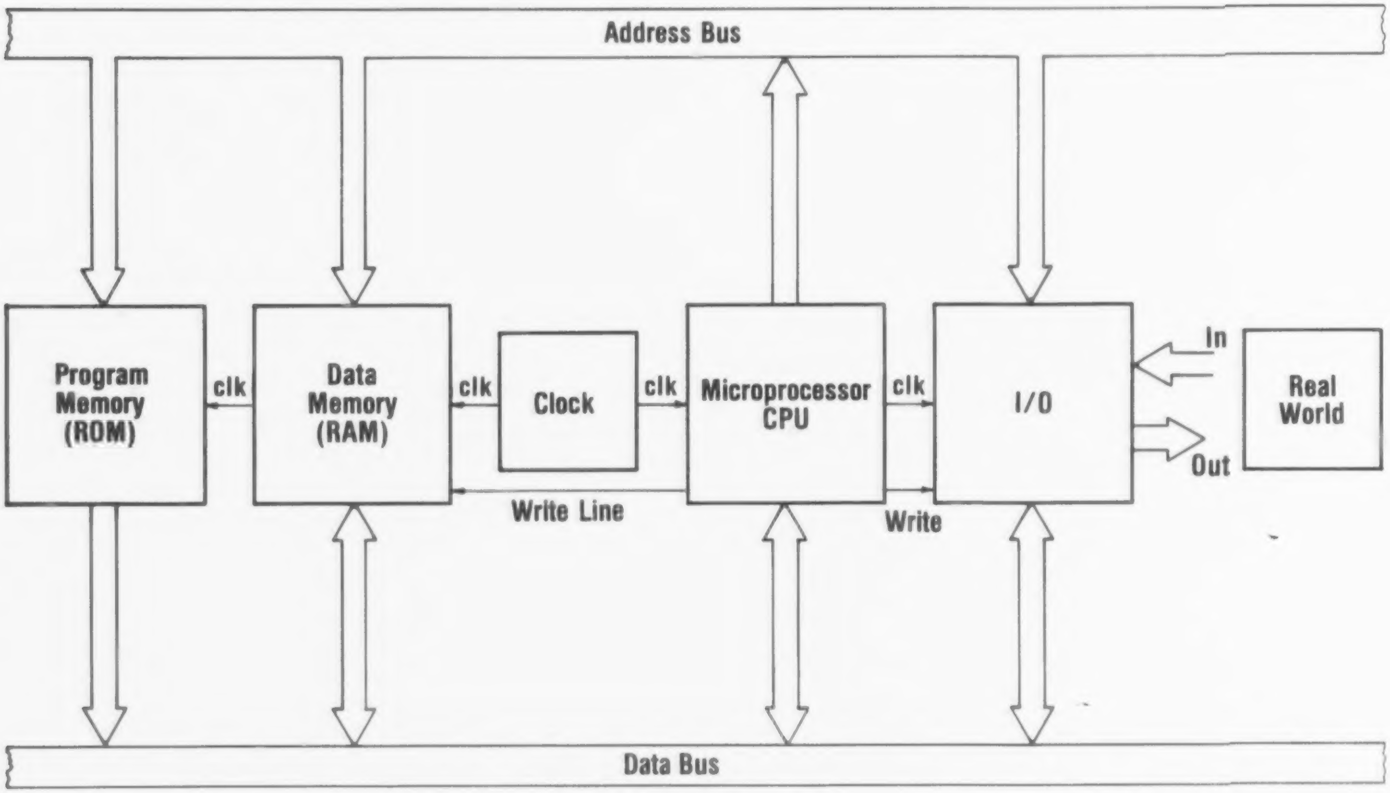
D. The data, address, and control busses

E. No

F. The control bus

G. The data bus is bidirectional

Assignment Sheet #2


Address Bus
Program Memory (ROM)
clk
Data Memory (RAM)
clk
Clock
clk
Microprocessor CPU
clk
I/O
In
Out
Real World
Write Line
Write
Data Bus

SYSTEM ARCHITECTURE
UNIT II

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. The capacity of a device to function effectively with another device or within a system

______b. Institute of Electrical and Electronics Engineers

______c. The temporary suspension of microcomputer activity in response to a priority command from another part of the system

______d. A way of describing memory devices that lose information stored in them when power is turned off

______e. A way of describing memory devices that retain information stored in them whether power is on or off

______f. The symbol for "phase" used on a schematic to indicate a time relationship between two electrical waveforms

1. Interrupt
2. Nonvolatile
3. IEEE
4. ϕ
5. Volatile
6. Compatibility

2. Select true statements concerning memory mapping by placing an "X" in the appropriate blanks.

______a. In a typical 8-bit microprocessor, memory is addressed by the address bus, and the different kinds of memory are usually grouped together so that RAM, ROM, and I/O addresses will be easy to find

______b. Memory mapping is a handy way of showing where the hex addresses begin and end for each type of memory, and the map is often a block diagram designed to help a programmer or troubleshooter better visualize memory locations

______c. A memory map for a typical 8-bit microprocessor will have RAM from hex locations $0000 to $7FFF, ROM from $8000 to $BFFF, and then I/O memory from $C000 to $FFFF

______d. When a system can send information out on the data bus to a peripheral or receive information from a peripheral via the data bus, it is said to be ported, and a memory mapped I/O port would usually have binary addresses following RAM and ROM

TEST

3. Complete the following statements concerning the importance of microprocessor control functions by inserting the word(s) that best completes each statement.

   a. The microprocessor is the nerve center that controls system operation, but the microprocesor in turn is controlled by software instructions that come in on the data bus:

      1) Software instructions can come from __________ to boot the system up

      2) Software instructions can come from __________ when the program has been written and stored in __________

      3) Software instructions can also be brought from the __________ or some other peripheral device and then __________ in memory

   b. Functions of the data and control busses are separate and unique:

      1) All data and instructions flow on the __________ bus

      2) All memory control is initiated by the microprocessor's addressing capability, and address information is usually sent to the system on the __________ bus

      3) All movement of data and instructions and all addressing is __________ in time by the system clock

   c. Knowing the __________ sets and __________ modes for a given microprocessor is essential for programming, but learning all the particulars is not necessary when a language such as BASIC is used

   d. When troubleshooting at the hardware level it is sometimes impossible to get a high level language to run the system, and a troubleshooter is sometimes called on to use __________ language to use the microprocessor directly

4. List the busses on a typical microcomputer.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

TEST

5. Complete the following statements concerning characteristics of the data bus by inserting the word(s) that best completes each statement.

   a. May be on a cable or PC board and consists of __________ parallel lines that simultaneously carry __________ binary 1's or 0's or combinations of the two

   b. The data bus carries information in 8-bit binary words to and from the __________ only

   c. The 8-bit binary word is synchronized by the system clock and since it can carry information to or from the microprocessor, it is __________

   d. The binary word may contain an __________, __________, or __________ information because all three types of information are required at various times for the microprocessor to perform computing tasks

6. Complete the following statements concerning characteristics of the address bus by inserting the word(s) that best completes each statement.

   a. May be on a cable or PC board and consists of __________ parallel lines that simultaneously carry __________ binary 1's or 0's or combinations of the two

   b. The address bus carries addresses generated by the microprocessor __________ __________ the microprocessor to some designated physical device such as __________, __________, or __________

   c. Information carried on the address bus may also identify a specific location within RAM, ROM, or I/O that the microprocessor may __________ __________ __________ as well as send information to

7. Complete the following statements concerning characteristics of the control bus by inserting the word(s) that best completes each statement.

   a. The control bus deals with __________ and direction of information

   b. The types of signals carried on the control bus normally include:

      1) __________ phase

      2) __________ signals

      3) __________ signals

   c. Specialized control bus functions vary from system to system, but in all cases, control signals are individual and are __________ __________ __________ __________ along parallel lines as the data and address signals are

TEST

8. Complete the following statements concerning characteristics of the system bus by inserting the word(s) that best completes each statement.

   a. The system bus frequently has slots where cards can be added to the system bus to provide ____________ system operations

   b. Expansion and interface boards and cards used to modify or enhance a system must be able to communicate with the system bus, and such boards are termed "____________"

   c. System busses are unique to specific microcomputers, and some system busses such as the S-100 and the SBC multibus have been ____________ by the IEEE

   d. System busses such as the Apple bus and the IBM bus have not been officially ____________, but they are so popular that some of them are "defacto" ____________ busses

9. Select true statements concerning busses and I/O relationships by placing an "X" in the appropriate blanks.

   _____a. In some early systems, communications with I/O devices was accomplished with "parallel bus latching," latching devices that latched information from the data bus to an outside peripheral or from an outside peripheral to the data bus

   _____b. The very earliest or peripheral chip I/O devices usually contained two ports that could carry 8 bits of data in either direction and could be controlled by data bits sent to the I/O devices on a control cycle

   _____c. The two-port structure permitted one parallel 8-bit port to be used as an output from the data bus and the other 8-bit port to be used as an input to the data bus, and all controlled by information sent to the peripheral device along the data bus

   _____d. Since some sort of address capability is required to map an I/O device into memory, this took the form of "chip select lines" on the I/O which in turn were connected through decoders to the address lines

   _____e. Chip select lines made it possible for an I/O device to be addressed as if it were memory for sending and receiving information in the form of parallel binary words and also for sending and receiving control signals to set up I/O devices

   _____f. As system became more sophisticated, it became obvious that parallel communications were the only way to work with I/O functions

TEST

_____g. As systems became more sophisticated, auxiliary functions were placed into I/O ports so the microprocessor would be freed of the time-consuming task of timing auxiliary operations

_____h. To further allow I/O devices to operate independently and report efficiently to the microprocessor, most of these I/O devices can generate interrupts to inform the microprocessor that a task is finished and then send and receive information to set up the next task

10. Complete the following statements concerning ROM's and their characteristics by inserting the word(s) that best completes each statement.

a. ROM sets up ____________ control in the microcomputer system and performs other control operations such as reading the keyboard, controlling information transfer to and from disk or tape, and controlling video display information

b. Because ROM is essential to control operations it must be ____________; it has to be there whether power is on or off

c. The type of ROM most commonly used is ____________ ROM which means that the original pattern of binary words necessary for control functions was placed permanently into the chip as it was manufactured by the OEM or by a specialty silicon foundry

d. Because of the design costs involved and the need to make a part cost effective, it was previously almost impossible for an end user to design ____________ ____________

e. Advances in chip technology have produced a type of nonvolatile memory that can be programmed by the ____________ ____________ and these are erasable programmable read only memories or EPROM's

f. EPROM's can be purchased for almost any microcomputer system and consists of a ____________ ____________ ____________ with a programming ____________ ____________ and a special socket to house the EPROM

g. Programs to be placed into EPROM's are usually written, stored in ____________, and then checked by running the program on the microcomputer

h. Even if a mistake is made in programming an EPROM, it can be erased by exposing it to ____________ light for approximately half an hour

i. Some EPROM's can be erased electrically and can actually be erased selectively by words or blocks, but because of their ____________ ____________ and ____________ ____________ they are not frequently used

TEST

11. Complete the following statements concerning read/write memories (RAM's) and their characteristics by inserting the word(s) that best completes each statement.

    a. For the purpose of troubleshooting and repair, the only concern is whether a RAM is ____________ or ____________

    b. A ____________ RAM is basically a flip/flop made of silicon while a ____________ RAM is an FET where binary 1's and 0's are stored in the capacitance of the FET device

    c. A ____________ RAM will hold its binary information pattern as long as power is maintained on the RAM or until changed by a control signal

    d. A ____________ RAM will hold a signal charge for about 1 to 2 milliseconds and then the memory must be refreshed in less time than the time required for the memory to be discharged

    e. The nature of static and dynamic RAM's affect troubleshooting in this fashion:

        1) In static RAM's, problems occur in only the ____________ and ____________/____________ functions

        2) In dynamic RAM's, problems occur not only in the ____________ and ____________/____________ functions, but also with the ____________ functions

    f. Since a ____________ RAM cell requires only a fraction of the space required by a ____________ RAM cell, the movement in RAM design is toward the high density ____________ RAM

    g. The ability to place large blocks of dynamic RAM on a single chip has made it easier to troubleshoot memory systems, and some dynamic RAM blocks even have a ____________ function on the chip which further simplifies the entire system

    h. The movement from 1K to 16K, 64K, and the trend toward the 256K, 512K, and even greater memory capacity will actually lead to ____________ components required to achieve maximum addressable memory and ____________ problems for the troubleshooter

12. Select true statements concerning timing circuits by placing an "X" in the appropriate blanks.

    _____a. The timing circuits which control clocking activities may be built into the microprocessor itself or may be located on a part external to the microprocessor

    _____b. Whether clock circuitry is on board or external, it must produce electrical signals appropriate to the decoding and execution of signals within the microprocessor

TEST

_____c. Whether on board or external, clock signals operate at the TTL level

_____d. A knowledge of all clocking functions is required for good troubleshooting, but the only clocks that troubleshooters have access to are the on board clocks

13. Complete the following statements concerning clock signals by inserting the word(s) that best completes each statement.

    a. Clock signals are recognizable by the waveform shapes they make on an oscilloscope, and these shapes are usually ____________

    b. Waveforms "pulse" at a rate determined by an external component or network and ____________ are most commonly used for this pulsing activity because of their low frequency drift characteristics

    c. The most common arrangement for clock signals is to have two signals that go positive at alternate times so that positive time segments do not ____________

    d. Because common clock signals contain two alternating signals, they are referred to as "____________-____________ ____________ ____________

    e. The purpose for having two signals timing functions within the system is to assure that the two basic functions of memory ____________ and ____________ transfer will not take place at the same time

14. Complete the following statements concerning clock phases by inserting the word(s) that best completes each statement.

    a. Clocking signals are referenced according to their functions as either:

        1) ____________

        2) ____________

    b. ____________ activity is concerned only with addressing

    c. ____________ activity is normally used only by the microprocessor because if any other component had control of the ____________ clock it would interfere with addressing activity

    d. ____________ activity is concerned with transfer of data within the system

15. Complete the following statements concerning other timing signals by inserting the word(s) that best completes each statement.

    a. Almost all microcomputer systems require more than ____________ signals for addressing and for data transfer

    b. ____________ signals are required for reading and writing to and from memory and other system parts such as I/O components

    c. In addition to clock and read/write signals, some systems require ____________ timing signals that may only be associated with a particular microprocessor

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

16. Solve problems related to system architecture and bus activity. (Assignment Sheet #1)

17. Diagram the relationship between the microprocessor and other system components in typical system architecture. (Assignment Sheet #2)

SYSTEM ARCHITECTURE
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 1
   d. 5
   e. 2
   f. 4

2. a,b,c

3. a. 1) ROM
      2) RAM, RAM
      3) Keyboard, stored
   b. 1) Data
      2) Address
      3) Synchronized
   c. Instruction, addressing
   d. Machine

4. a. Data bus
   b. Address bus
   c. Control bus
   d. System bus

5. a. 8, 8
   b. Microprocessor
   c. Bidirectional
   d. Instruction, data, address

6. a. 16, 16
   b. Out from, RAM, ROM, I/O
   c. Receive information

7. a. Timing
   b. 1) Clock
      2) Read/write
      3) Interrupt
   c. Not sent in sync

8. a. Enhanced
   b. Compatible
   c. Standardized
   d. Standardized, standardized

9. a,b,c,d,e,g,h

ANSWERS TO TEST

10. a. Initial
    b. Nonvolatile
    c. Masked
    d. Nonvolatile ROM
    e. End user
    f. Printed circuit card, voltage supply
    g. RAM
    h. Ultraviolet
    i. Low speed, high cost

11. a. Static, dynamic
    b. Static, dynamic
    c. Static
    d. Dynamic
    e. 1) Addressing, read/write
       2) Addressing, read/write, refresh
    f. Dynamic, static, dynamic
    g. Decoding
    h. Fewer, fewer

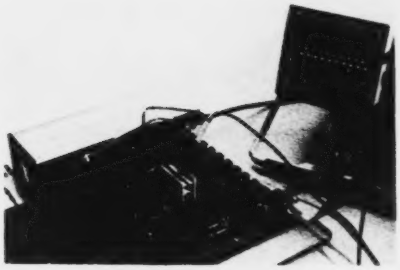
12. a,b,c

13. a. Rectangular
    b. Crystals
    c. Overlap
    d. Two-phase nonoverlapping clocks
    e. Addressing, data

14. a. 1) $\phi 1$ or phase one
       2) $\phi 2$ or phase two
    b. $\phi 1$ or phase one
    c. $\phi 1$, ϕ 1 or phase one
    d. $\phi 2$ or phase two

15. a. Timing
    b. Timing
    c. Special

16. Evaluated to the satisfaction of the instructor
17. Evaluated to the satisfaction of the instructor



MICROPROCESSOR ARCHITECTURE AND TIMING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the architecture of representative 8-bit microprocessors used in contemporary microcomputers and compare clocking and timing functions of microprocessors. The student should also be able to read pinout diagrams, test timing waveforms on an oscilloscope, and evaluate a driver program to check RAM. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to microprocessor architecture and timing with their correct definitions.
2. Differentiate between major elements of microprocessor architecture.
3. Complete statements concerning architecture of the 6502 microprocessor.
4. Select true statements concerning electrical characteristics of the 6502.
5. Complete statements concerning architectural features of the 6502.
6. Complete statements concerning architecture of the 8080A microprocessor.
7. Select true statements concerning electrical characteristics of the 8080A.
8. Complete statements concerning architectural features of the 8080A.
9. Complete comparisons between the 8080A and 8085 microprocessors.

QBJECTIVE SHEET

10. Complete statements concerning architecture of the Z-80 microprocessor.
11. Select true statements concerning features that enhance Z-80 performance.
12. Complete statements concerning electrical characteristics of the Z-80.
13. Select true statements concerning architectural features of the Z-80.
14. Complete statements concerning architecture of the 6800 microprocessor.
15. Select true statements concerning electrical characteristics of the 6800.
16. Select true statements concerning architectural features of the 6800.
17. Complete comparisons of the 6800 and 6802 microprocessors.
18. Complete statements concerning architecture of the 8088 microprocessor.
19. Select true statements concerning characteristics of the 8088 group registers.
20. Select true statements concerning the 8088 instruction set.
21. Complete statements concerning the significance of timing functions.
22. Solve problems concerning waveform interpretations.
23. Complete a list of other signals related to clock timing.
24. Interpret a line diagram of 6502 clock timing.
25. Interpret a typical 6500/6800 cycle for reading data from memory or peripherals.
26. Interpret a typical 6500/6800 cycle for writing data to memory or peripherals.
27. Complete statements concerning instruction sets.
28. Select true statements concerning instructions that move data.
29. Select true statements concerning instructions for internal transfer.
30. Complete statements concerning instructions for arithmetic and logic functions.
31. Complete statements concerning instructions for decision making.
32. Select true statements concerning instructions for comparison.
33. Complete statements concerning instructions for indexing.
34. Select true statements concerning instructions for internal operations.

OBJECTIVE SHEET

35. Complete statements concerning instructions for special operations.

36. Complete statements concerning addressing modes.

37. Match addressing modes with their characteristics.

38. Complete statements concerning interrupts and how they work.

39. Differentiate between types of interrupts.

40. Complete statements concerning the OPCODE and operands.

41. Demonstrate the ability to:

    a. Write and run a machine language driver program to check a read/write memory (RAM) location. (Job Sheet #1)

    b. Write and run a driver program for making expanded read/write memory (RAM) checks. (Job Sheet #2)

MICROPROCESSOR ARCHITECTURE AND TIMING
UNIT III

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheet.

F. Discuss and demonstrate the procedures outlined in the job sheets.

G. Demonstrate the use of a dual-trace oscilloscope in evaluating timing signals and emphasize the variations in appearance between schematics of timing signal waveforms and the waveforms actually screened on the oscilloscope.

H. Select an instruction set from the group included in this unit and demonstrate to the students the way in which instructions are used to move data, to perform arithmetic and logic functions, to make decisions, to accomplish internal register transfer, and to perform single byte operations as well as transfer, and to perform single byte operations as well as miscellaneous operations.

I. Check the job sheets carefully and use them as guides for preparing RAM check driver programs for the microcomputers available for your students to work with.

J. Examine the test and select a mid-point or a place where it can be divided in two parts because it is a long test and should not be administered in one long testing session.

K. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Transparency masters

   1. TM #1 — Pinout — 6502 Microprocessor
   2. TM #2 — 6502 Addressing Modes
   3. TM #3 — Pinout — 8080A Microprocessor
   4. TM #4 — 8080A Addressing Modes
   5. TM #5 — Pinout — 8085 Microprocessor

CONTENTS OF THIS UNIT

6. TM #6 — Pinout — Z-80 Microprocessor
7. TM #7 — Z-80 Addressing Modes
8. TM #8 — Pinout — 6800 Microprocessor
9. TM #9 — 6800 Addressing Modes
10. TM #10 — Pinout — 8088 Microprocessor
11. TM #11 — 6502 Clock Timing
12. TM #12 — Clock and Read/Write Timing Table for 1 MHz Operation
13. TM 13 — 6500/6800 Cycle for Reading Data from Memory to Peripherals
14. TM #14 — 6500/6800 Cycle for Writing Data to Memory or Peripherals
15. TM #15 — Instruction Set — 6502
16. TM #16 — Instruction Set — 6502 (Continued)
17. TM #17 — Instruction Set — 6809/6800
18. TM #18 — Instruction Set — 6809/6800 (Continued)
19. TM #19 — Instruction Set — 8080/8085
20. TM #20 — Instruction Set — 8080/8085 (Continued)
21. TM #21 — Instruction Set — Z-80
22. TM #22 — Instruction Set — Z-80 (Continued)

D. Job sheets

1. Job Sheet #1 — Write and Run a Machine Language Driver Program to Check a Read/Write Memory (RAM) Location
2. Job Sheet #2 — Write and Run a Driver Program for Making Expanded Read/Write Memory (RAM) Checks

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Brey, Barry D. *Microprocessor/Hardware Interfacing and Applications.* Columbus, OH 43216: Charles E. Merrill Publishing Company, 1984.

B. Drischoll, Frederick F. *Microprocessor-Microcomputer Technology.* North Scituate, MA 02060: Breton Publishers, a division of Wadsworth, Inc., 1983.

C. Tocci, Ronald J., and Lester P. Laskowski. *Microprocessors and Microcomputers.* Englewood Cliffs, NJ 07632: Prentice-Hall, Inc., 1979.

D. Zumchak, Eugene. *Microcomputer Design and Troubleshooting.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1982.

E. *MCS6500 Microcomputer Programming Manual.* Norristown, PA 19401: MOS Technology, Inc., 1976.

F. *IPAX 86, 88 User's Manual.* Santa Clara, CA 95051: Intel Corporation, 1981.

MICROPROCESSOR ARCHITECTURE AND TIMING
UNIT III

INFORMATION SHEET

I. **Terms and definitions**

A. Symmetrical — A waveform in which the two halves appear to be approximately the same shape

B. Rise time — The time it takes for a waveform to rise from 10% of total amplitude to 90% of total amplitude

C. Fall time — The time it takes for a waveform to fall from 90% total amplitude to 10% total amplitude

D. Qualified high — That time at which a waveform has passed a point in rise time to reach a functioning logic level of high

E. Qualified low — That time at which a waveform has passed a point in fall time to reach a functioning logic level of low

F. $\phi 1$ — The symbol and number (spoken as phase one) used to reference the phase one clock or the memory addressing phase of the clock function

G. $\phi 2$ — The symbol and number (spoken as phase two) used to reference the phase two clock or the addressing and data phase of the clock function

(NOTE: Some systems refer to the clocks as A and B or by other designations, but their functions are still the same.)

H. $ — Symbol used to indicate a hexadecimal

II. **Major elements of microprocessor architecture**

A. Internal architecture — The architecture that controls operations of the microprocessor through internal hardware including registers, encoders, decoders, and busses

B. External architecture — The architecture that connects the key parts of the system, the microprocessor, the memories, and the I/O's, through some kind of common bus structure

(NOTE: The microprocessors discussed in the following objectives were selected because they are best representative of the microprocessor architecture that technicians will confront frequently in troubleshooting and repair work.)

INFORMATION SHEET

III. **Architecture of the 6502 microprocessor (Transparency 1)**

A. An 8-bit microprocessor both internally and externally

B. Programmer accessible registers:

1. The accumulator
2. The stack pointer
3. Index register X
4. Index register Y
5. Program counter
6. Status register with 7 flags

C. Flag functions:

1. Zero flag
2. Carry flag
3. Sign flag (negative flag)
4. Overflow flag
5. Special flags:
    a) An interrupt mask
    b) A break flag that indicates when software has halted the system
    c) A decimal flag for putting arithmetic operations into decimal mode

D. Hidden registers — Include an instruction register and I/O data latches

IV. **Electrical characteristics of the 6502** (Transparency 1)

A. Uses a +5V power supply

B. Is manufactured in versions ranging from 1 MHz to a high-speed 10 MHz version

C. System clock is on the 6502 chip

INFORMATION SHEET

V. **Architectural features of the 6502** (Transparency 1)

   A. Has a unique system of internal data busses that allow for high speed direct and indirect addressing, and this is an outstanding feature of the 6502

   B. The program counter will generate a 16-bit address although it is actually done by two 8-bit program counters

   C. Has 3 vectored interrupts:

      1. $\overline{\text{IRQ}}$

      2. $\overline{\text{NMI}}$

      3. $\overline{\text{RES}}$ or $\overline{\text{RST}}$

   D. Has 56 instructions in its instruction set

   E. Has 13 addressing modes which include pre- and post-index indirect addressing, and this is a special feature of the 6502 (Transparency 2)

VI. **Architecture of the 8080A microprocessor (Transparency 3)**

   A. An 8-bit microprocessor both internally and externally

   B. Programmer accessible registers common to most of the other 8-bit microprocessors

   C. Special registers not common to other microprocessors

      1. One accumulator which is a single 8-bit register and referred to as "the" accumulator or the "A" accumulator

      2. Six secondary registers that can be used to do internal data manipulations, and these registers are labeled: B, C, DE, and HL

      3. These special 8-bit registers can be paired internally so that two together can perform 16-bit arithmetic or logic operations

      4. Although loading the 8-bit registers still requires working through the 8-bit data bus, loading is not faster, but the paired function for logic and arithmetic is much faster

   D. In addition to the "A" register and the secondary registers there are:

      1. A 16-bit stack pointer

      2. A 16-bit program counter

      3. An 8-bit flag register which uses only 5 bits for flags

INFORMATION SHEET

E. Another special feature of the 8080A is the temporary multiplexer that works with the ALU much like an accumulator does to feed into the paired registers via another pair of hidden registers labeled the W and Z registers

F. Another 8080A feature is the special incrementer and decrementer latch ahead of the buffers which is used as an output for the 16-bit address

VII. **Electrical characteristics of the 8080A** (Transparency 3)

A. Uses three power supply voltages, +12V, +5V, and -5V

B. System clock is external to the 8080A chip and requires at least two other microprocessor support IC's:

1. An 8224 clock driver and generator

2. An 8228 systems controller and bus driver

C. The 8224 chip contains:

1. The oscillator which receives the external crystal signals for timing

2. A clock generator which takes the oscillator signal and creates the $\phi 1$ and $\phi 2$ outputs

3. The reset input for the system

4. Some control logic for internal purposes

D. The 8228 chip contains:

1. A bidirectional bus driver

2. A status latch for sending information from the 8080A to the outside system control bus

(NOTE: This arrangement is required because the status signals appear on the data bus during part of the setup and provide information necessary for control functions such as read/write.)

VIII. **Architectural features of the 8080A** (Transparency 3)

A. Has only one interrupt labeled $\overline{\text{INT}}$

B. Uses a bus enable signal to tell the microprocesser when to pass information through the bus to the microprocessor and when to wait

C. Has 78 instructions in its instruction set

D. Has only four addressing modes (Transparency 4)

INFORMATION SHEET

IX. **Comparisons between the 8080A and 8085 microprocessors** (Transparencies 3 and 5)

A. Knowing the architecture of the 8080A will make it much easier to understand the architecture of the 8085 because of their major differences

B. The major difference between the two is that the 8085 requires only one +5V power supply while the 8080A requires three different voltages

C. Another important difference is that the 8085 has two extra functions to deal exclusively with serial I/O, and these pins are identified as:

1. SID (serial input of data)
2. SOD (serial output of data)

D. Another important difference is that the 8085 does not require the 8224 and 8228 external chips to support the clock because the clock is internal

E. Another difference is that the 8080A has a single interrupt while the 8085 has additional interrupts available with RIM (read interrupt mask) and SIM (set interrupt mask) instructions

Example: By reading the interrupt mask, a programmer can tell which flags have been set by interrupts, and if flags need to be set in a particular order, the programmer can set them with SIM instruction

F. The 8085 also has multiplexed address lines

X. **Architecture of the Z-80 microprocessor (Transparency 6)**

A. An 8-bit microprocessor both internally and externally

B. Programmer accessible registers common to most of the other 8-bit microprocessors

(NOTE: Remember that the Z-80 models the 8080A architecture to a point so it will be beneficial to compare the two at certain points to better understand the operational characteristics of the Z-80.)

C. The Z-80 has all of the main registers found in the 8080A plus an alternate set of registers that duplicates the main register set so that there are:

1. Two "A" accumulators
2. Two flag registers
3. Twelve secondary registers

INFORMATION SHEET

D. Since there needs to be a way to clearly identify the alternate set of registers, they are referred to as:

   1. A' accumulator
   2. B' accumulator
   3. C' accumulator
   4. DE' accumulator
   5. HL' accumulator

   (NOTE: The superlinear marks to the right of the letters should be called out as A prime, B prime, etc.)

E. The Z-80 also has the following 16-bit registers:

   1. An index register marked IX
   2. A second index register marked IY
   3. A stack pointer
   4. A program counter

XI. **Features that enhance Z-80 performance**

A. The double registers in the Z-80 provide six 16-bit registers for use inside the microprocessor, and since a faster clock speed is another Z-80 enhancement, it means that the Z-80 can perform number crunching much faster than earlier model 8-bit microprocessors

B. The two 16-bit index registers IX and IY give the Z-80 high speed and wide-ranging indexing capability

C. The Z-80 has an 8-bit vector interrupt register to increase the interrupt capability

XII. **Electrical characteristics of the Z-80** (Transparency 6)

A. Uses one +5V power supply

B. System clock is on the Z-80 chip

INFORMATION SHEET

XIII. **Architectural features of the Z-80** (Transparency 6)

- A. Has 158 instructions in its instruction set
- B. Encompasses the 8080A instruction set, and enhances it with instructions broken into the following instruction blocks:
    1. 8-bit loads and 16-bits loads
    2. 16-bit
    3. Exchanges, block transfers, and searches
    4. 8-bit arithmetic and logic operations
    5. General purpose arithmetic and microprocessor control
    6. 16-bit arithmetic
    7. Rotates and shifts
    8. Bit set, reset, and testing
    9. Jumps
    10. Subroutine calls, returns, and I/O operations
- C. Has 9 addressing modes (Transparency 7)

XIV. **Architecture of the 6800 microprocessor (Transparency 8)**

- A. An 8-bit microprocessor both internally and externally
- B. Program accessible registers:
    1. Accumulator A
    2. Accumulator B

       (NOTE: The two accumulator design is unique to the 6800 because both have equal power for arithmetic and logic functions, and the B accumulator doesn't have a secondary status as with other 8-bit microprocessors.)
    3. A 16-bit index register marked IX
    4. A 16-bit program counter
    5. A 16-bit stack pointer

       (NOTE: All 16-bit registers can be loaded internally by using successive 8-bit operations.)
    6. Condition code register with 6 flags

       (NOTE: Other microprocessors refer to this as the flag register or status register.)

INFORMATION SHEET

C. Condition code (flag) functions:

1. Carry flag
2. Half-carry flag
3. Zero flag
4. Sign flag
5. Overflow flag
6. Interrupt mask flag

   (NOTE: A unique feature of the 6800 is that two additional locations in the condition code register are held in a high position at all times.)

XV. **Electrical characteristics of the 6800** (Transparency 8)

A. Uses a single +5V power supply

B. Requires an external clock generator such as the MC6871 or the MC6875

XVI. **Architectural features of the 6800** (Transparency 8)

A. Hidden registers include the instruction register, I/O data latch, address buffers and latches, and ALU

B. Has a bidirectional data bus

C. Although it is an 8-bit microprocessor both internally and externally, it functions as 16-bits all the time

(NOTE: This is possible because loading 16 bits into a register requires the use of two 8-bit words.)

D. Has three vectored interrupts

1. $\overline{\text{IRQ}}$
2. $\overline{\text{NMI}}$
3. $\overline{\text{RES}}$ or $\overline{\text{RST}}$

E. Has 72 instructions in its instruction set

F. Has seven addressing modes (Transparency 9)

INFORMATION SHEET

XVII. Comparisons of the 6800 and 6802 microprocessors

A. Knowing the architecture of the 6800 will make it much easier to understand the architecture of the 6802 because of their basic similarities

B. The 6802 architecture varies from the 6800 in only two ways:

1. The clock is on the 6802 so an extra component is eliminated

2. 128 bytes of on board RAM have been added with a battery power source to retain 32 bytes even after power is turned off, and the remaining serves as additional RAM

XVIII. Architecture of the 8088 microprocessor (Transparency 10)

A. A 16-bit microprocessor internally but is specifically designed to behave like an 8-bit microprocessor

(NOTE: This is an outstanding feature of the 8088 because it serves as a transitional vehicle between 8-bit and 16-bit architecture since 8-bit word organized devices can be interfaced with the 8088.)

B. Programmer addressable registers are broken down into three major groups of four registers each and one additional group of single-purpose registers:

1. Data group registers:

   a. Accumulator

   b. Base

   c. Count

   d. Data

2. Pointer and index group registers:

   a. Stack pointer

   b. Base pointer

   c. Source index

   d. Destination index

3. Segment registers

   (NOTE: These will be clarified in a later objective.)

4. Single-purpose registers:

   a. 16-bit instruction pointer

   b. 16-bit flag register

INFORMATION SHEET

XIX. **Characteristics of the 8088 group registers**

A. Data group registers are not limited to traditional register functions as their names might indicate because they all serve multiple functions

B. Data group registers are designed to act as a subset of 8-bit registers that will mimic the true 8-bit operations of the 8080 and 8085 microprocessors

C. Pointer and index group registers have traditional functions with arithmetic and logic

D. Pointer and index group registers also have powerful features such as instructions that multiply and divide, perform string operations, and access large amounts of memory in the index mode by using the 8088's unique address segmentation technique

E. Segment registers are used to create offsets within the entire span of the 64K memory blocks to allow the addressing of multiple 64K byte segments of memory so that a programmer literally has available up to 1 megabyte of memory

(NOTE: Although the 8088 data bus is only 8 bits wide, the 16-bit operations for address segmentation are accomplished by feeding information into the 16-bit register via an instruction queue.)

F. The single-purpose registers serve traditional functions because the 16-bit instruction pointer is the same as a program counter, and the 16-bit flag register dedicates its lower 8 bits to the same flag functions found in the 8080A or 8085

(NOTE: However, the flag registers in the high byte of the 8088 are unique to 16-bit microprocessor operations.)

XX. **The 8088 instruction set**

A. Compared to the instruction sets for the 6502 and 6800, the instruction set for the 8088 is long and complex

(NOTE: For a detailed listing of the 8088 instruction set, consult Intel's *iAPX 86, 88 User's Manual,* but the instruction set is so long and complex that it is not included in this unit.)

B. In machine language, the 8088 instruction set has approximately 300 instructions

C. In assembly language, the 8088 instruction set has approximately 100 instructions

XXI. **Significance of timing functions**

A. Timing manages the orderly activity within a microcomputer system, and the electrical pulses that constitute timing signals produce waveforms that can be screened on an oscilloscope and evaluated

INFORMATION SHEET

B. For a waveform to rise from zero to peak value takes a certain amount of time, and to fall from peak value to zero takes a certain amount of time, and these rise and fall times are critical to timing

C. There is a short time delay between the time that $\phi1$ clock becomes qualified high and the time that $\phi2$ clock becomes qualified low, and this short time delay is to insure that the two waveforms do not overlap

(NOTE: This nonoverlapping aspect of timing is critical in all 8-bit microprocessors, but especially in the 8085 which multiplexes both addresses and data on the same set of pins.)

XXII. **Waveform interpretations**

A. Waveforms are usually shown in schematics or in line diagrams so that the nonoverlapping aspect of the two clock signals can be properly represented in time

B. When troubleshooting, remember that the waveforms shown on the oscilloscope screen may look quite different from line diagram or schematic waveforms because:

1. Overshoot of the waveform because of energy stored in the system
2. Loss of high or low frequency response causing the waveform to be rounded off or otherwise changed in shape
3. Loss of waveform information caused by triggering the oscilloscope

C. Using an oscilloscope as a troubleshooting tool requires learning how to equate the oscilloscope waveform picture with the diagrammed picture

D. Oscilloscope waveforms should never be hastily evaluated or it may lead a troubleshooter to assume a problem when no problem is present

XXIII. **Other signals related to clock timing**

A. Read/write signals

B. What occurs on the address and data busses with respect to memory

(NOTE: Since the 6502/6800 and the 8080A/8085 microprocessors are representative of 8-bit microprocessors with respect to timing, memory, and other control functions, they are used as examples in this unit of instruction so that their similarities may also be used to stress differences in various other systems.)

INFORMATION SHEET

XXIV. **6502 clock timing** (Transparency 11)

A. Clock phases are symmetrical but opposite

B. The high going parts of both $\phi 1$ clock and $\phi 2$ clock are shorter than the low going parts of $\phi 1$ clock and $\phi 2$ clock

C. Only one typical data line is needed to show how all address lines work (Transparency 11)

D. Other abbreviations used to clarify timing diagrams include (Transparency 13)

1. TCYC — Cycle time
2. TR — Rise time
3. TF — Fall time
4. TD — Delay time
5. PWH — Clock pulse width
6. TMDS — Data setup time

XXV. **Typical 6500/6800 cycle for reading data from memory or peripherals** (Transparency 13)

A. After $\phi 1$ clock has become qualified high, the read/write line will begin to change, if it is necessary for it to change, and this is shown as TRWS (read/write setup time)

B. In a case where data is being read from memory, during the time for read/write setup, the read/write line will go high if it isn't already high

C. During the TRWS for the read/write line, the address lines also change, and the time for address setup is shown as TADS (address setup time)

D. Since TRWS and TADS take place simultaneously, it means that the read/write and address lines both set up and start when $\phi 1$ clock is at qualified high, not when it is in rise time

E. The next occurance during reading data from memory or a peripheral is the presentation of data to the data bus line, and this occurs when $\phi 2$ clock goes to qualified low, not when it is in fall time

F. After data is transferred to the data bus line, the time that the data is actually available from the memory to the bus becomes critical, and this data stability time period in both the 6500 and 6800 chips is identified as TDSU (data stability time period)

INFORMATION SHEET

G. The data stability factor is critical to the total timing function because it must be long enough or longer to work within the limitations of a memory chip

(NOTE: Data transfer time is always noted in memory chip specifications and is stated in nanoseconds.)

H. On the 6502 line diagram, TH (data hold time) means how long data remains available after $\phi 2$ clock goes to qualified low

(NOTE: Data hold time is usually very short and in some systems set at zero to avoid the possibility of holding too long and interferring with the next timing cycle.)

XXVI. **Typical 6500/6800 cycle for writing data to memory or peripherals** (Transparency 14)

A. Waveforms for writing data look like waveforms for reading data, but clock references change:

1. When reading from memory or peripherals $\phi 2$ clock has to be at qualified low, but for writing from the microprocessor to memory or peripherals, the $\phi 2$ clock has to be at qualified high
2. When reading data from memory, the read/write line goes high, but when writing data to memory or peripherals, the read/write line goes low

B. TMDS or data setup time starts after the $\phi 2$ clock has gone to qualified high so it will have the remainder of the $\phi 2$ clock cycle to transfer data into memory or peripherals

C. The DBE signal, data bus enable, is usually identical with the $\phi 2$ clock signal, and when DBE is high, data bus transfers can occur

(NOTE: The DBE is found on the 6800 product line.)

XXVII. **Instruction sets** (Transparencies 15, 16, 17, 18, 19, 20, 21, and 22)

A. Instruction sets consist of codes that a microprocessor will recognize so that it can perform a specific programmed activity

B. Instruction sets are handy for a troubleshooter because they can be used to write driver programs that will operate a component that needs evaluation

INFORMATION SHEET

C. Instruction sets are grouped into general categories according to their functions:

1. Instructions that move data
2. Instructions that perform arithmetic and logical functions
3. Instructions that make decisions
4. Instructions that perform internal register transfer
5. Instructions that perform single byte operations
6. Instructions that perform miscellaneous operations

XXVIII. Instructions that move data

A. The movement of data is usually the first part of an instruction set because the movement of data is critical to the entire system operations

Example: Data is first obtained by addressing, then moved to the microprocessor so it can be operated on, then the results will require moving the data back into memory or to an I/O port or some other part of the system, so moving data is not only the first activity in a program operation, it is usually the last task performed in a program routine

B. None of the operations normally performed by a microprocessor can be performed without data, so instructions that move data are the most frequently used instructions in system operations

XXIX. Instructions for internal transfer

A. Instructions for internal transfer move data and, sometimes, address information from one register or temporary storage location inside the microprocessor to another location inside the microprocessor

B. Internal transfer instructions all take place inside the microprocessor itself and because of this, these operations are usually very fast

(NOTE: In other words, internal instructions, unlike data movement instructions, do not go out to memory or I/O devices.)

XXX. Instructions for arithmetic and logic functions

A. In most cases, the reason for bringing information into a microprocessor is for the microprocessor to perform an arithmetic or logical function with the information and for that reason arithmetic and logical operations are the major functions of a microprocessor

(NOTE: If arithmetic or logical operations are not required, simple information movement and comparisons could be made by routine logic chips far less expensive than a microprocessor chips.)

INFORMATION SHEET

B. When it performs logical functions, the microprocessor works like a logic gate in performing AND, OR, and EOR operations

(NOTE: The real value of the logical operations is that when the microprocessor behaves as if it were a physical logic gate, it can normally handle more bits of logic than most logic gates can.)

C. When it performs arithmetic functions, the typical 8-bit microprocessor can only add and subtract, and even then the ALU is mostly an adder and must complete a 2's complement of one of the numbers to be added in order to perform subtraction

D. In most cases, logical shifting of the data word is used in multiplying and dividing with the adder-type microprocessor, so shift instructions make it possible to multiply and divide efficiently

XXXI. Instructions for decision making

A. Instructions for decision making follow movement, internal transfer, and arithmetic/logic operations because this is the point where a decision must be made concerning the information that has been acted upon

Example: The decision making process determines if the operations are producing a certain result, if the operation is complete, or if some other operation might be required

B. Decision making is based on the status of the last operation that was performed by the previous instruction

C. The status is reflected in "status bits" which are normally referred to as "flags" and decision making is based on the presence of the flag "high" or the absence of the flag "low"

D. In almost all 8-bit microprocessors, high flag is represented by logic 1 and low flag is represented by logic 0

E. In almost all 8-bit microprocessors, there are three basic flags:

1. Zero flag
2. Algebraic sign flag (positive or negative)
3. Carry flag

(NOTE: The types of decisions that can be made depend on the status flags available in a microprocessor and available flags vary among microprocessors.)

INFORMATION SHEET

F. A variation of decision making found in many microprocessors permits a facility to move to a location other than the next location in a program and this involves:

1. Branching or making a decision as to how far to go
2. Jumping or making a decision to go to a specific address location

G. There are two types of jumps:

1. Conditional, which refers back to decision making because a decision may be involved in whether or not to jump
2. Unconditional, which means the program will jump to a new location without a decision, and in turn, the unconditional jump may be:
    a. Ordinary, which means the program will not return to the place it jumped from
    b. Jump to subroutine, which means the program will perform the subroutine and then return to the place in the program that it jumped from

H. Conditional and unconditional jumps have one thing in common in that they can move the program counter, and these are usually the only kinds of instructions that can move the program counter

XXXII. **Instructions for comparison**

A. Instructions for comparison in most 8-bit microprocessors are variations of normal subtraction activity that takes place in the ALU

(NOTE: When subtraction takes place in the ALU, the results are stored in a register called the "accumulator" because it accumulates the answer, so when subtraction does take place, whatever was in the the accumulator previously is destroyed when new information is placed in the accumulator.)

B. In a comparison instruction, the binary number to be compared is placed into the accumulator and is compared with another number by subtracting the second number from the number placed in the accumulator

C. In a comparison instruction, the result is not stored in the accumulator, rather, the result is discarded and the results of the comparison (subtraction) are indicated by the status flag

(NOTE: The comparison procedure means that a programmer can continue to compare numbers contained in the accumulator over and over again, and the accumulator may also be compared with things in RAM and ROM locations and even index registers.)

INFORMATION SHEET

XXXIII. Instructions for Indexing

A. Instructions for indexing are used frequently in two types of program operations:

1. Counting, where the index is a number set into a register or memory location to cause the program to repeat a certain operation a given number of times

2. Table operations, where the index is used for table loading or table storage

   Example: If a programmer wanted to load a table with information from I/O, the successive pieces of information coming from the input could be indexed in such a way that each piece of information would go to a unique memory location to create a complete table of successive values found at the input, and a similar technique is used for sending information stored in memory tables to peripherals such as printers or screen displays

B. Index literally means to change register contents by one in either direction, subtract one from a location or add one to a location

1. Subtracting is called "decrementing" the index

2. Adding is called "incrementing" the index

C. In several 8-bit microprocessors, there are specific index registers that are either 8-bits long or double length, 16-bits long

(NOTE: Since addresses used by microprocessors are almost always 16-bits long, the double length, 16-bit index registers permit a 16-bit indexing capability so that a specific memory may be indexed or indexing can be accomplished through the entire memory if it is needed.)

INFORMATION SHEET

XXXIV. Instructions for internal operations

A. Instructions for internal operations vary among microprocessors because in each microprocessor there is a unique set of internal registers

B. To deal with an internal register set requires special internal instructions which in some cases may designate a specific bit location inside a register

Example: In most 8-bit microprocessors, the instructions to locate and set the zero flag are instructions for internal operations

C. Although they may have impact on some external parts of a microcomputer, stack operations are considered to be internal in nature

D. The stack is simply a location in memory where the contents of an internal register can be kept when it is necessary to temporarily save them

(NOTE: Some microprocessors have stack operations inside, but most use external memory for stack operations.)

Example: Subroutines often use the registers inside a microprocessor, so when going to a subroutine, if the register contents are not stored somewhere else, the contents of the program will be destroyed

XXXV. Instructions for special operations

A. Instructions for special operations vary among microprocessors because in most microprocessors there are a few instructions unique to a particular microprocessor and they do not fit neatly into any group or block

B. Other special instructions are so termed because of the purposes they serve although they may not be unique to a given system

(NOTE: NOP (no operation) is an instruction found in many systems, yet it does not fit into any general category because its only function is to change the program counter to the next location in memory.)

XXXVI. Addressing modes

A. Addressing modes provide the freedom to use an instruction with more than one type of register or memory

B. Instructions for performing some general operation do not have to be rewritten for each register, and this saves time and provides flexibility

Example: When using the add instruction in the microprocessor, if one could only add from a specific memory type, then it would require writing add instructions for each memory type or each register, and this might require ten to twelve add instructions where one or two instructions might accomplish the same objective by using the addressing modes

INFORMATION SHEET

XXXVII. Addressing modes and their characteristics

A. Implied or inherent — An addressing mode in which the instruction is completely self-contained in the OPCODE and there is no data or addressing required for the instruction to know where to go and what type of operation to perform

B. Immediate — An addressing mode in which the instruction OPCODE is followed immediately by an 8-bit data word which is operated on by the instruction, and the address of the data is understood to be the next immediate location in memory

C. Absolute or extended — An addressing mode in which data is given in a full 16-bit address following the instruction OPCODE and the instruction operates on the 16-bit address

(NOTE: Implied and immediate addressing modes provide faster operation because the absolute mode must fetch information after sending out a 16-bit address.)

D. Relative — An addressing mode which allows performance of some instruction indicated by the OPCODE on an address that is relative to some location; usually that "relative" location is the current location of the program counter

Example: A relative branch can branch from the present location of the program counter to a distance specified in the OPCODE, and since the address is relative to the program counter, it can be used anywhere in memory without the regard to the location of the memory, and this provides program flexibility

E. Indexed — An addressing mode in which the location that the instruction OPCODE will operate on is dependent on the contents of the index specified in the instruction and allow a programmer to create very short blocks of code that will store or evaluate long tables of information

Example: If a programmer wishes to perform an operation on a specific location in a table, there is no need to know the location of that particular item in memory, only how far to index from the beginning of the table so that the table can be examined or stored without having to write the address of each specific item in the table, and the "indexed" addressing mode provides a programmer with a tremendous flexibility that would not otherwise be available

INFORMATION SHEET

F. Indirect — An addressing mode in which the address that follows the instruction OPCODE is the address of an address so that an indirect instruction means the OPCODE must first go to the location given by the program to find the address of the data to be operated on

Example: The indirect addressing mode could be compared to going to a strange town and looking for a friend because that procedure would usually means stopping at a pay phone at a service station to call your friend for directions to the address you're really looking for, or in other words, you find your friend's address by going "indirectly" to another address first

(NOTE: There are variations of addressing modes among microprocessors, but the modern trend in 8-bit microprocessors is toward shorter instruction sets and more powerful addressing modes so that maximum power can be achieved with instruction sets that are short and easy to remember.)

G. Direct — An addressing mode in which part of the instruction details the way the address is found during an instruction cycle

Example: The OPCODE in a direct instruction is followed by either one or two bytes of code that presents the address to be operated on by the microprocessor, so the microprocessor goes "direct" to the address that follows the OPCODE

H. Zero page — An addressing mode where one and only one byte of code follows the OPCODE to indicate an address found in zero page of memory

Example: A programmer wanting to speed up operations would use zero page addressing because it requires only half the normal space in an instruction and runs faster than other addressing modes

XXXVIII. Interrupts and how they work

A. An interrupt is a signal that will cause a microprocessor to stop what it is doing and perform some other previously programmed operation

B. Almost all 8-bit microprocessors have interrupt functions in order to deal with outside world functions that operate in real time

Example: Most microprocessors operate with clocks which run in multiple million cycle clocking times, but physical operations that take place outside the microprocessor cannot and do not run anywhere near that fast

INFORMATION SHEET

C. An interrupt permits the microprocessor to continue functioning economically while interacting with outside world input

Example: If the microprocessor were forced to wait during the delay-time it takes for a programmer to move from one key press to the next key press, the microprocessor would waste a tremendous number of cycles which could otherwise be dedicated to performing working instructions — in other words, even a speedy programmer can make a key press, on the average, every 300 milliseconds, but in that same time the microprocessor can perform close to one and a third million clock operations, so the interrupt provides the microprocessor with the facility to continue program operation at its own speed even when repeated interrupts follow one after the other

D. An interrupt permits external asynchronous input into the microprocessor so it can be used for multiple purposes

Examples: If a microprocessor is set to control environmental functions in a home and it is also desired that the microprocessor act as a security system, it would be impractical to have the microprocessor continually monitor the status of every window and door because the better way would be to tie the security function into the interrupt system of the microprocessor so that improper access of any door or window would cause the microprocessor to sound an alarm or send a phone line alert to local law enforcement officials

XXXIX. **Types of interrupts**

A. Request interrupt — An interrupt with a nonemergency priority so that the interrupt signal will get the microprocessor's attention but not be executed until the microprocessor has finished the operation with which it is currently working

B. Nonmaskable interrupt — An interrupt with an emergency priority that signals the microprocessor to stop instantly what it is doing and accept interrupt instructions

Example: In many new computer designs, the built-in memory protection cycle sends an interrupt signal when voltage to the computer starts to fail, and this nonmaskable interrupt immediately tells the microprocessor to store vital information before the power drops below the level required for performing memory storage operations

INFORMATION SHEET

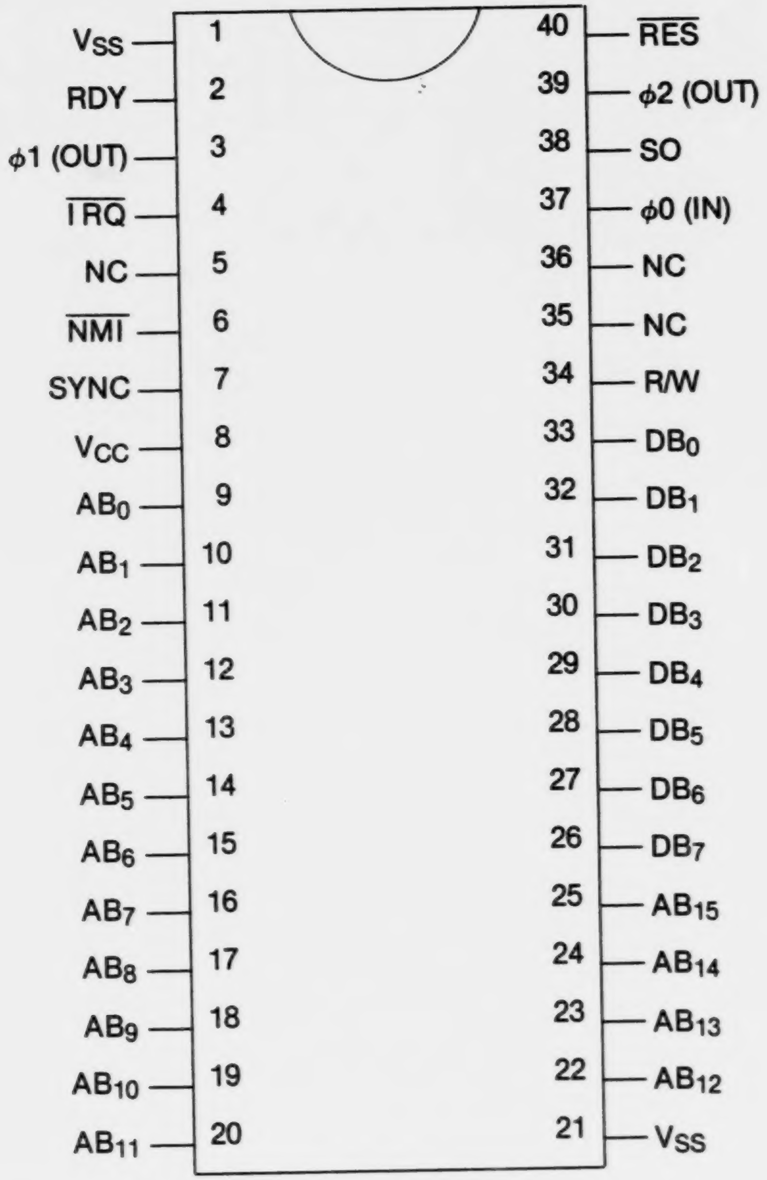
XXXX. **The OPCODE and operands**

A. Each 8-bit microprocessor has only 256 unique binary numbers that may be specified by an 8-bit binary word, and these unique numbers are called OPCODES

B. An OPCODE tells the microprocessor the nature of the operation to be performed, what registers to set up, and even the addressing involved in each program step

C. Other instructions, operands, follow the OPCODE, and these instructions are generic according to program needs, but OPCODES are unique

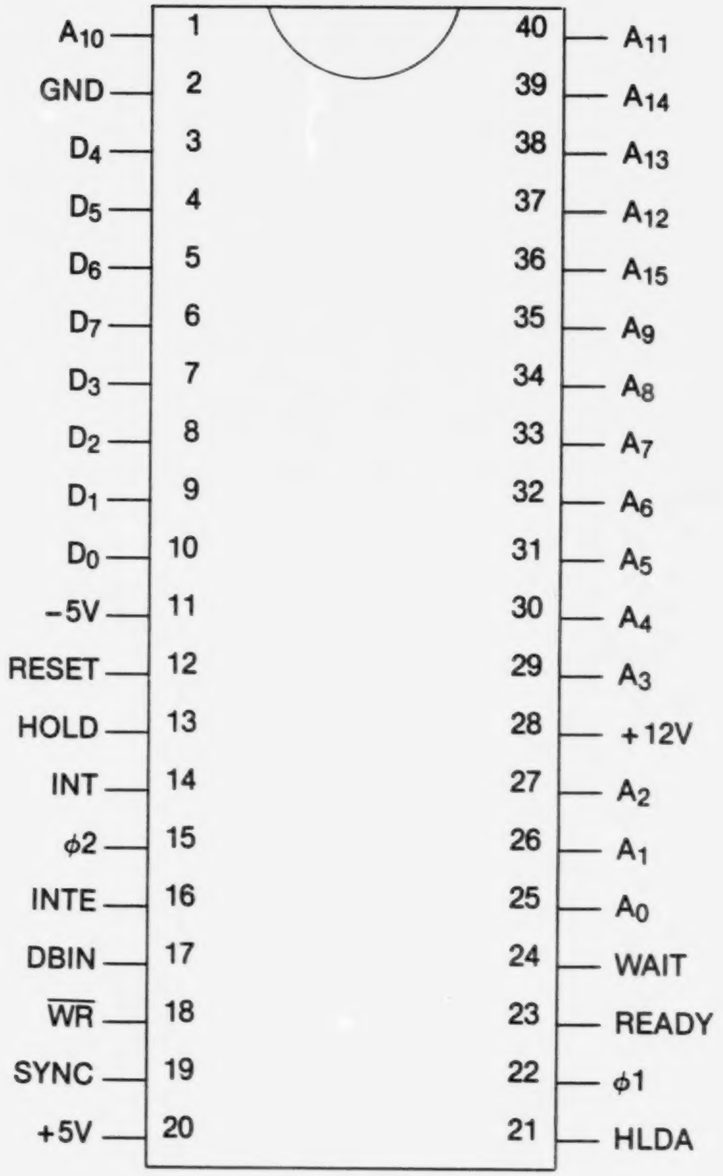
Pinout — 6502 Microprocessor


V_{SS} 1
RDY 2
ϕ1 (OUT) 3
$\overline{IRQ}$ 4
NC 5
$\overline{NMI}$ 6
SYNC 7
V_{CC} 8
AB_0 9
AB_1 10
AB_2 11
AB_3 12
AB_4 13
AB_5 14
AB_6 15
AB_7 16
AB_8 17
AB_9 18
AB_{10} 19
AB_{11} 20
40 $\overline{RES}$
39 ϕ2 (OUT)
38 SO
37 ϕ0 (IN)
36 NC
35 NC
34 R/W
33 DB_0
32 DB_1
31 DB_2
30 DB_3
29 DB_4
28 DB_5
27 DB_6
26 DB_7
25 AB_{15}
24 AB_{14}
23 AB_{13}
22 AB_{12}
21 V_{SS}

6502 Addressing Modes

1. Implied
2. Immediate
3. Absolute
4. Accumulator
5. Zero page
6. Index X
7. Index Y
8. Zero page index X
9. Zero page index Y
10. Relative
11. Indirect
12. Indirect index
13. Index indirect

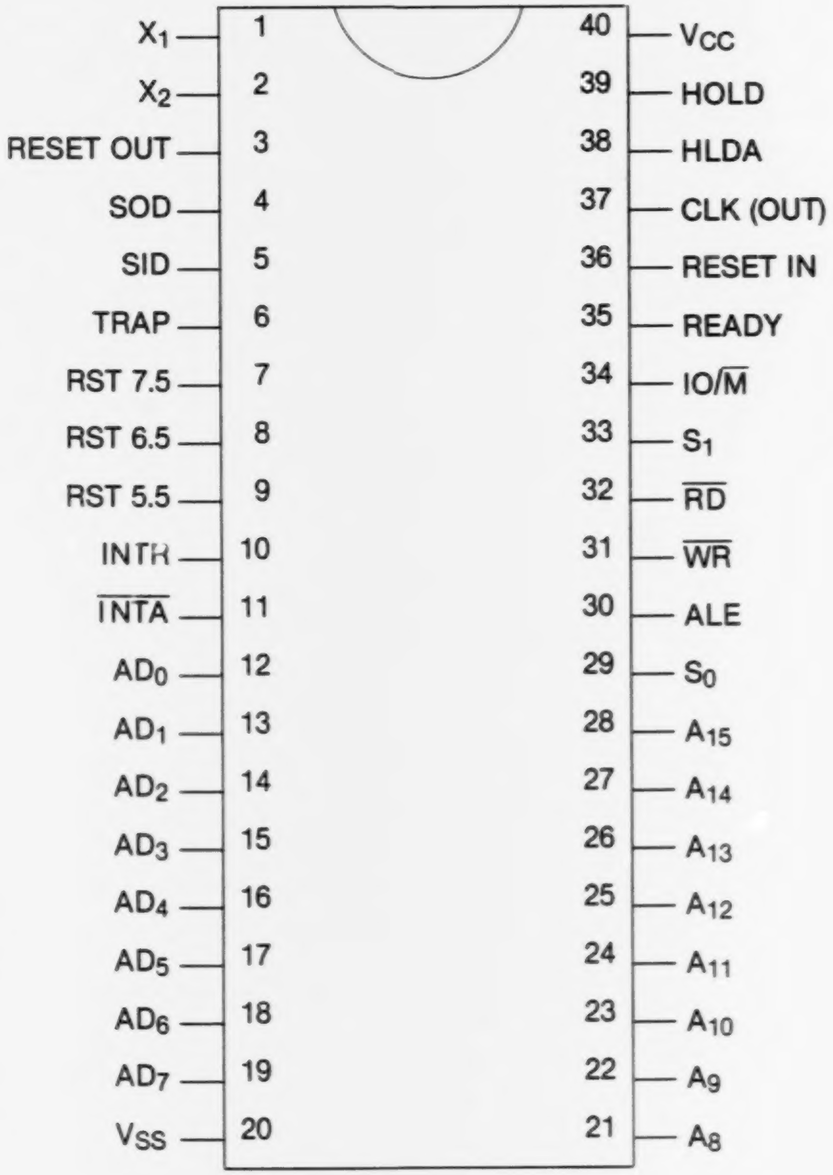
Pinout — 8080A Microprocessor


A_{10} 1 40 A_{11}
GND 2 39 A_{14}
D_4 3 38 A_{13}
D_5 4 37 A_{12}
D_6 5 36 A_{15}
D_7 6 35 A_9
D_3 7 34 A_8
D_2 8 33 A_7
D_1 9 32 A_6
D_0 10 31 A_5
−5V 11 30 A_4
RESET 12 29 A_3
HOLD 13 28 +12V
INT 14 27 A_2
$\phi 2$ 15 26 A_1
INTE 16 25 A_0
DBIN 17 24 WAIT
$\overline{WR}$ 18 23 READY
SYNC 19 22 $\phi 1$
+5V 20 21 HLDA

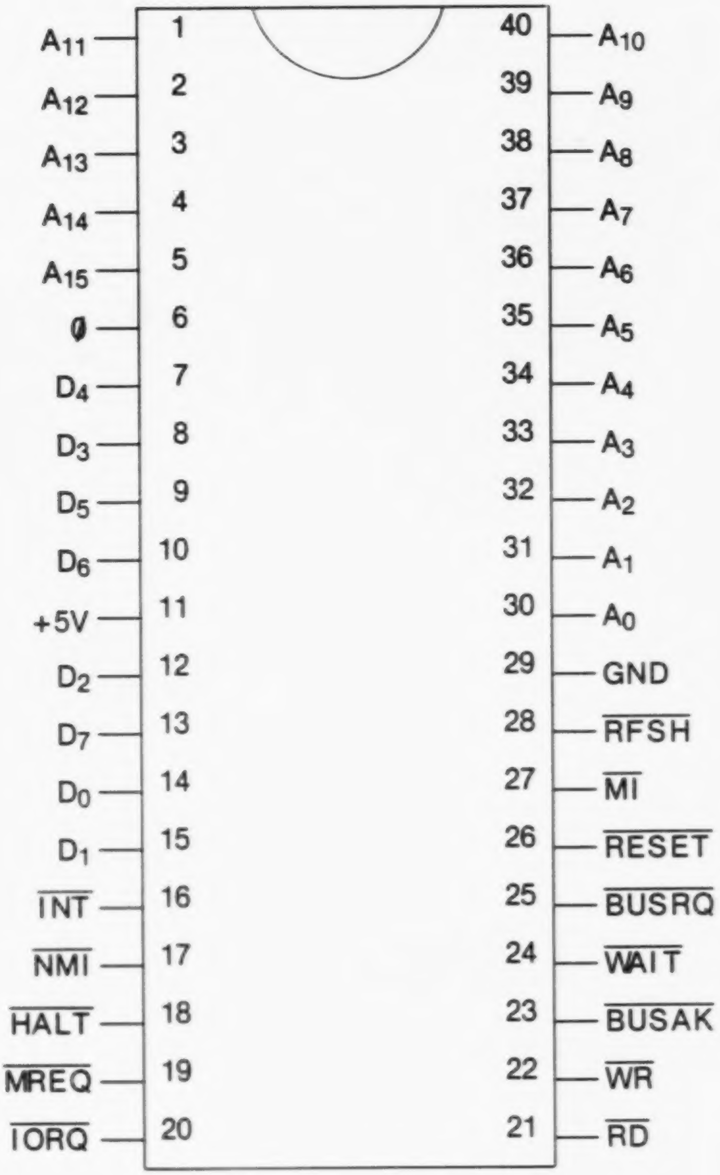
8080A Addressing Modes

1. Direct
2. Register
3. Register indirect
4. Immediate

Pinout — 8085 Microprocessor


X_1 1
X_2 2
RESET OUT 3
SOD 4
SID 5
TRAP 6
RST 7.5 7
RST 6.5 8
RST 5.5 9
INTR 10
$\overline{INTA}$ 11
AD_0 12
AD_1 13
AD_2 14
AD_3 15
AD_4 16
AD_5 17
AD_6 18
AD_7 19
V_{SS} 20
40 V_{CC}
39 HOLD
38 HLDA
37 CLK (OUT)
36 RESET IN
35 READY
34 $IO/\overline{M}$
33 S_1
32 $\overline{RD}$
31 $\overline{WR}$
30 ALE
29 S_0
28 A_{15}
27 A_{14}
26 A_{13}
25 A_{12}
24 A_{11}
23 A_{10}
22 A_9
21 A_8

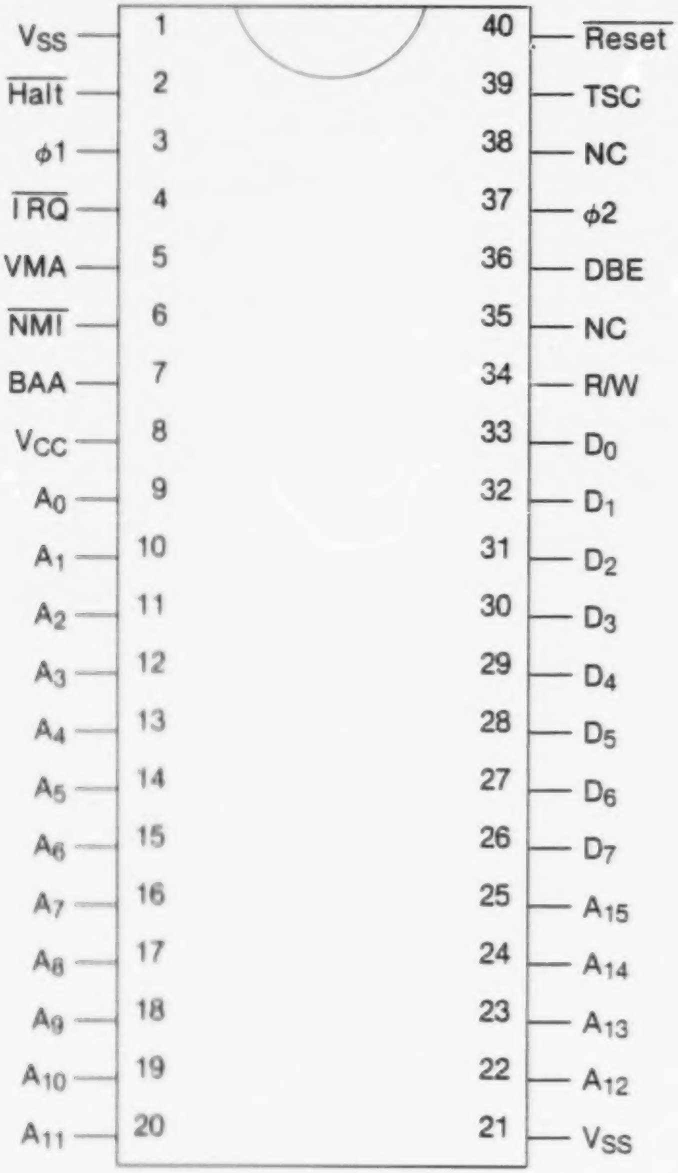
Pinout — Z-80 Microprocessor


A11 1
A12 2
A13 3
A14 4
A15 5
Ø 6
D4 7
D3 8
D5 9
D6 10
+5V 11
D2 12
D7 13
D0 14
D1 15
INT 16
NMI 17
HALT 18
MREQ 19
IORQ 20
40 A10
39 A9
38 A8
37 A7
36 A6
35 A5
34 A4
33 A3
32 A2
31 A1
30 A0
29 GND
28 RFSH
27 MI
26 RESET
25 BUSRQ
24 WAIT
23 BUSAK
22 WR
21 RD

Z-80 Addressing Modes

1. Immediate
2. Immediate extended
3. Modified zero page
4. Relative
5. Extended
6. Register
7. Register indirect
8. Implied
9. Bit

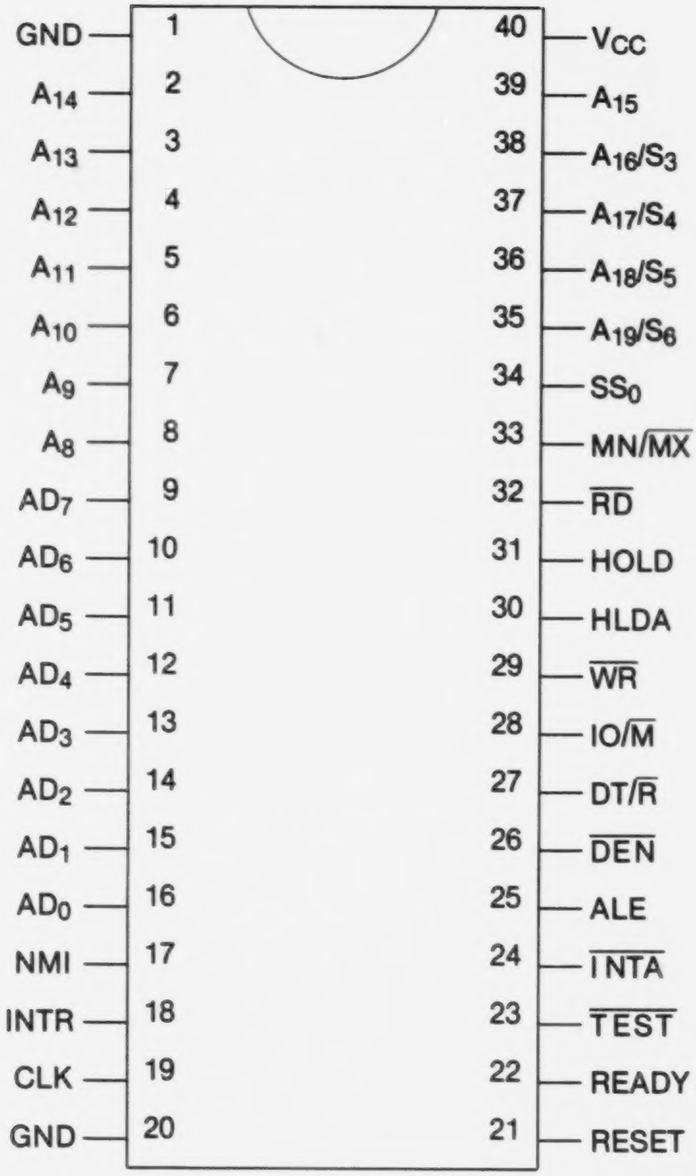
Pinout — 6800 Microprocessor


V_{SS} 1
$\overline{Halt}$ 2
$\phi 1$ 3
$\overline{IRQ}$ 4
VMA 5
$\overline{NMI}$ 6
BAA 7
V_{CC} 8
A_0 9
A_1 10
A_2 11
A_3 12
A_4 13
A_5 14
A_6 15
A_7 16
A_8 17
A_9 18
A_{10} 19
A_{11} 20
40 $\overline{Reset}$
39 TSC
38 NC
37 $\phi 2$
36 DBE
35 NC
34 R/W
33 D_0
32 D_1
31 D_2
30 D_3
29 D_4
28 D_5
27 D_6
26 D_7
25 A_{15}
24 A_{14}
23 A_{13}
22 A_{12}
21 V_{SS}

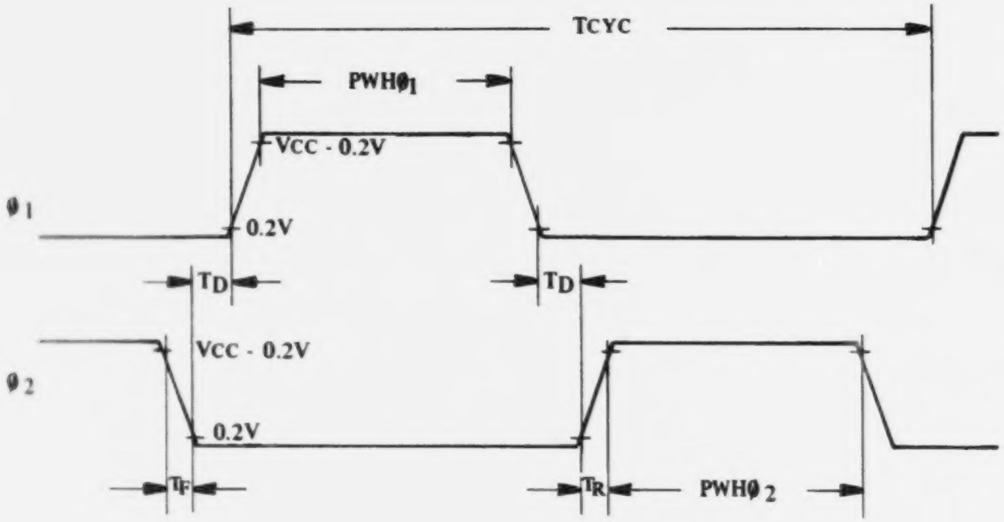
6800 Addressing Modes

1. Direct
2. Implied
3. Immediate
4. Accumulator
5. Relative
6. Extended or Absolute
7. Index

Pinout — 8088 Microprocessor


GND 1
A_{14} 2
A_{13} 3
A_{12} 4
A_{11} 5
A_{10} 6
A_9 7
A_8 8
AD_7 9
AD_6 10
AD_5 11
AD_4 12
AD_3 13
AD_2 14
AD_1 15
AD_0 16
NMI 17
INTR 18
CLK 19
GND 20
40 V_{CC}
39 A_{15}
38 A_{16}/S_3
37 A_{17}/S_4
36 A_{18}/S_5
35 A_{19}/S_6
34 SS_0
33 $MN/\overline{MX}$
32 $\overline{RD}$
31 HOLD
30 HLDA
29 $\overline{WR}$
28 $IO/\overline{M}$
27 $DT/\overline{R}$
26 $\overline{DEN}$
25 ALE
24 $\overline{INTA}$
23 $\overline{TEST}$
22 READY
21 RESET

6502 Clock Timing


TCYC
PWHØ1
VCC - 0.2V
Ø1
0.2V
TD
TD
VCC - 0.2V
Ø2
0.2V
TF
TR
PWHØ2

Courtesy Commodore Business Machines, Inc.

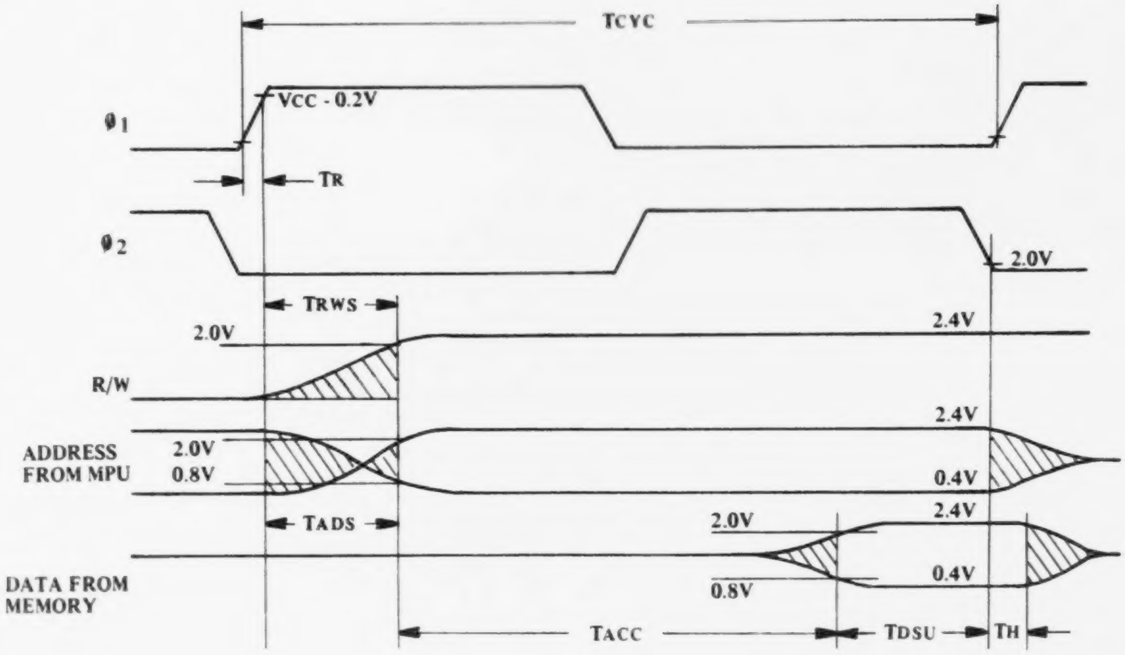
Clock and Read/Write Timing Table for 1 MHz Operation

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Cycle Time	T_{CYC}	1.0 µs	--	--	µsec
Clock Pulse Width Ø1 (Measured at Vcc-0.2v) Ø2	PWH Ø1 PWH Ø2	430 430	--	--	nsec
Rise and Fall Times (Measured from 0.2V to Vcc-0.2V)	T_F, T_R	--	--	25	nsec
Delay time between Clocks (Measured at 0.2V)	T_D	0	--	--	nsec

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Read/Write Setup Time from MCS650X	T_{RWS}	--	100	300	ns
Address Setup Time from MCS650X	T_{ADS}	--	200	300	ns
Memory Read Access Time T_R T_{CYC} - (T_{ADS} - T_{DSU} - tr)	T_{ACC}	--	--	500	ns
Data Stability Time Period	T_{DSU}	100	--	--	ns
Data Hold Time	T_H	10	30	--	ns
Enable High Time for DBE Input	T_{EH}	430	--	--	ns
Data Setup Time from MCS650X	T_{MDS}		150	200	ns

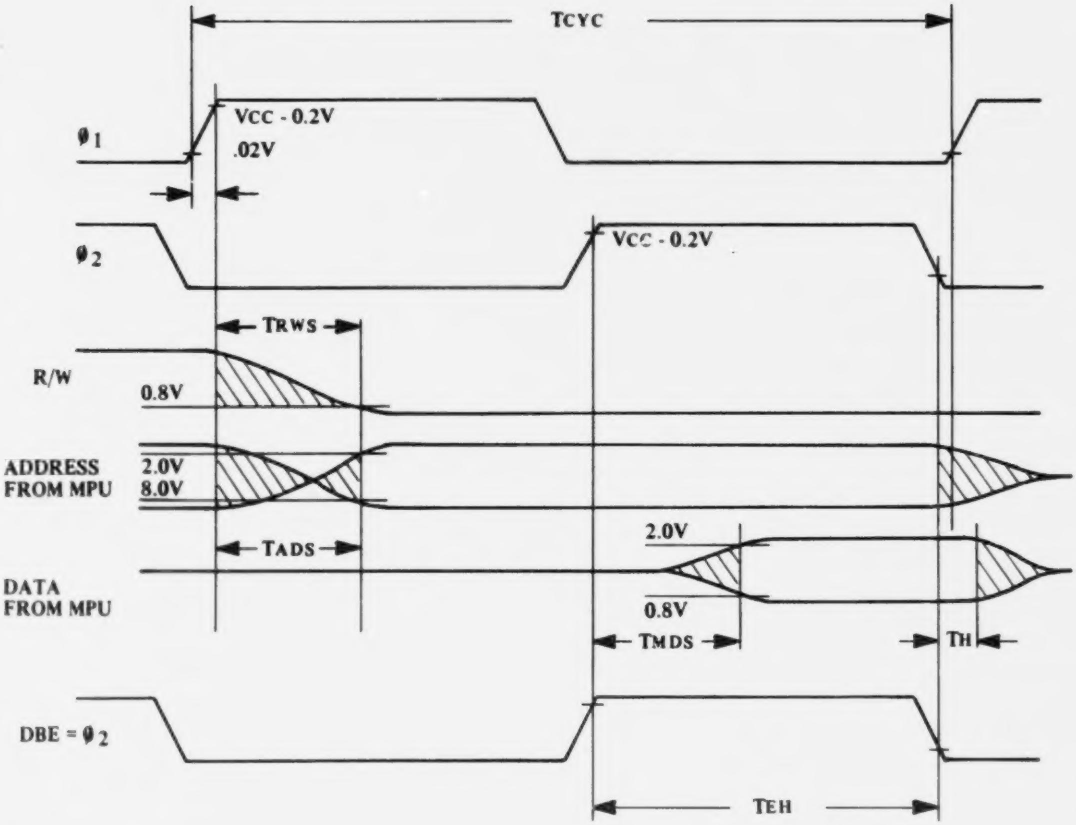
Courtesy Commodore Business Machines, Inc.

6500/6800 Cycle for Reading Data From Memory or Peripherals


TCYC
φ1
VCC - 0.2V
TR
φ2
2.0V
TRWS
2.0V
2.4V
R/W
2.4V
ADDRESS FROM MPU
2.0V
0.8V
0.4V
TADS
2.0V
2.4V
DATA FROM MEMORY
0.8V
0.4V
TACC
TDSU
TH

Courtesy Commodore Business Machines, Inc.

6500/6800 Cycle for Writing Data To Memory or Peripherals


TCYC
Ø1
VCC - 0.2V
.02V
Ø2
VCC - 0.2V
TRWS
R/W
0.8V
ADDRESS FROM MPU
2.0V
8.0V
TADS
DATA FROM MPU
2.0V
0.8V
TMDS
TH
DBE = Ø2
TEH

Courtesy Commodore Business Machines, Inc.

Instruction Set — 6502

DATA MOVEMENT

LDA	Load Accumulator with Memory
LDX	Load Index X with Memory
LDY	Load Index Y with Memory
STA	Store Accumulator in Memory
STX	Store Index X in Memory
STY	Store Index Y in Memory

INTERNAL TRANSFER

TAX	Transfer Accumulator to Index X
TAY	Transfer Accumulator to Index Y
TXS	Transfer Index X to Stack Pointer
TXA	Transfer Index X to Accumulator
TSX	Transfer Stack Pointer to Index X
TYA	Transfer Index Y to Accumulator

ARITHMETIC

ADC	Add Memory to Accumulator with Carry
ASL	Shift Left One Bit (Memory or Accumulator)
LSR	Shift Right One Bit (Memory or Accumulator)
ROL	Rotate One Bit Left (Memory or Accumulator)
ROR	Rotate One Bit Right (Memory or Accumulator)
SBC	Subtract Memory from Accumulator with Borrow

LOGICAL

AND	"AND" Memory with Accumulator
EOR	"Exclusive-Or" Memory with Accumulator
ORA	"OR" Memory with Accumulator

DECISION

BCC	Branch on Carry Clear
BCS	Branch on Carry Set
BEQ	Branch on Result Zero
BMI	Branch on Result Minus
BNE	Branch on Result not Zero
BPL	Branch on Result Plus
BVC	Branch on Overflow Clear
BVS	Branch on Overflow Set

Instruction Set — 6502
(Continued)

JUMPS

JMP	Jump to New Location
JSR	Jump to New Location Saving Return Address

COMPARISON

BIT	Test Bits in Memory with Accumulator
CMP	Compare Memory and Accumulator
CPX	Compare Memory and Index X
CPY	Compare Memory and Index Y

INDEXING

DEC	Decrement Memory by One
DEX	Decrement Index X by One
DEY	Decrement Index Y by One
INC	Increment Memory by One
INX	Increment Index X by One
INY	Increment Index Y by One

INTERNAL

CLC	Clear Carry Flag
CLD	Clear Decimal Mode
CLI	Clear Interrupt Disable Bit
CLV	Clear Overflow Flag
PHA	Push Accumulator on Stack
PHP	Push Processor Status on Stack
PLA	Pull Accumulator from Stack
PLP	Pull Processor Status from Stack
RTI	Return from Interrupt
RTS	Return from Subroutine
SEC	Set Carry Flag
SED	Set Decimal Mode
SEI	Set Interrupt Disable Status

SPECIAL

BRK	Force Break
NOP	No Operation

Instruction Set — 6809/6800

DATA MOVEMENT

TFR	Move, 8-bit
EXG	
CLR	
LD	
ST	
TFR	Move, 16-bit
EXG	
LD	
ST	
LEA	Load effective address
PSHS	Move, bytes
PSHU	
PULS	
PULU	

INDEXING

INC	Increment
INC	
INC	
DEC	Decrement
DEC	
DEC	
COM	Complement
COM	
OR	Set selected CC bits
AND	Clear selected CC bits

ARITHMETIC

ADD	Add, 8-bit
ADC	Add with carry, 8-bit
DAA	Decimal adjust acc.A
ADD	Add, 16-bit
ABX	
SEX	Sign extend
SUB	Subtract, 8-bit
SBC	Subtract with carry, 8-bit
NEG	Negate
NEG	
SUB	Subtract, 16-bit
MUL	Multiply

AND	AND
EOR	Exclusive-OR
OR	OR (inclusive)

COMPARISONS

CMP	Compare, 8-bit
TST	
TST	
BIT	
CMP	Compare, 16-bit

SHIFTS & ROTATES

ROL	Rotate left
ROL	
ROR	Rotate right
ROR	
ASL	Arithmetic shift left
ASL	
ASR	Arithmetic shift right
ASR	
LSL	Logic shift left
LSL	
LSR	Logic shift right
LSR	

SPECIAL

NOP	No operation

Instruction Set — 6809/6800

(Continued)

DECISIONS

JMP	Jump unconditionally
BRA	Branch unconditionally
BCS	if carry set
BCC	if carry clear
BEN	if not equal zero
BEQ	if equal zero
BMI	if minus
BPL	if plus
BVS	if overflow set
BVC	if overflow clear
BGT	if > zero
BGE	if ≥ zero
BLE	if ≤ zero
BLT	if ≤ zero
BHI	if higher
BHS	if higher or same
BLS	if lower or same
BLO	if lower

JUMPS

JSR	Jump to subroutine
BSR	Branch to subroutine
RTS	Return from subroutine

SPECIALS

SWI	Software interrupt
SWI2	
SWI3	
CWAI	Clear and wait
SYNC	Synchronize I/O
RTI	Return from interrupt

Instruction Set — 8080/8085

DATA MOVEMENT

IN	Input
LDA	Load accumulator absolute
LDAX	Load accumulator via register indirect
LHLD	Load HL pair using absolute address
LXI	Load immediate to register pair
MOV	Move one byte
MVI	Move immediate byte to register
OUT	Output
SHLD	Store HL pair using absolute address
STA	Store accumulator using absolute address
STAX	Store accumulator using register indirect

INTERNAL TRANSFER

PCHL	Replace program counter with contents of HL
POP	Pop data from stack to register pair
RET	Return from subroutine
SPHL	Stack pointer replaced by HL pair
XCHG	Exchange DI and HL register pairs
XTHL	Exchange top two stack bytes and HL pair

ARITHMETIC

ACI	Add with carry immediate to accumulator
ADC	Add with carry to accumulator
ADI	Add without carry immediate to accumulator
ADD	Add without carry to accumulator
DAD	16-Bit add register pair to HL pair
RAL	Rotate accumulator left through carry
RAR	Rotate accumulator right through carry
RLC	Rotate accumulator left with MSB to carry
RRC	Rotate accumulator right with LSB to carry
SBB	Subtract from accumulator with borrow
SUI	Subtract from accumulator immediate

LOGICAL

ANA	And with accumulator
ANI	And with accumulator immediate
CMA	Complement (one's) accumulator
CMC	Complement carry bit
ORA	OR with accumulator
ORI	OR with accumulator immediate
XRA	Exclusive OR with accumulator
XRI	Exclusive OR with accumulator immediate

INDEXING

DCR	Decrement register
DCX	Decrement register pair by one
INR	Increment register
INX	Increment register pair

Instruction Set — 8080/8085
(Continued)

INTERNAL

RET	Return from subroutine

COMPARISON

CMP	Compare with accumulator

SPECIAL

DAA	Decimal adjust accumulator
DI	Disable interrupt
EI	Enable interrupt
HLT	Halt
NOP	No operation
RST	Restart
STC	Set carry
RIM	Read Input mask
SIM	Set Input mask

JUMP

CALL	Call subroutine
JMP	Jump

Instruction Set — Z-80

LOAD COMMANDS

LD A	Load the accumulator (Accumulator may be loaded with locations BE, DE, I, or nn)
LD (BC) A	Load location BC with acc.
LD (HL) A	Load location HL with acc. (There are more than 30 load commands that permit loading of locations with given values)
LDD	Load location DE with location HL, decrement DE, HL, and BC (LDDR; LDI; and LDIR are all load, decrement, and increment commands)
OTDR	Load outport port C with location HL, decrement HL, decrement B, repeat until B=0 (OTIR; OUT (C) r; OUT (n), A; OUTD; and OUTI are all load output port commands)
POP IX	Load IX with top of stack
POP IY	Load IY with top of stack
POPqq	Load regular pair qq with top of stack
PUSH IX	Load IX onto stack
PUSH IY	Load IY onto stack

ROTATE COMMANDS

RL m	Rotate left through carry operand m
RLA	Rotate left acc. through carry
RR m	Rotate right through carry operand m
RRA	Rotate right acc. through carry (RLC(HL); RLC(IX+d); RLC(IY+d); RLCr; RLCA; RLD; RRCm; RRCA; and RRD are all rotate commands)

SHIFT COMMANDS

SLA m	Shift operand m left arithmetic
SRA m	Shift operand m right arithmetic
SRL m	Shift operand m right logical

ADD COMMANDS

ADC HL,ss	Add with carry reg. pair ss to HL
ADC A,s	Add with carry operand s to acc. (ADD A,n: ADD A,r; Add A, (HL); Add A,(IX+d); ADD A(IY+d); ADD HL,ss; ADD IX,pp; and ADD IY,rr are all add commands)

COMPARE COMMANDS

CP s	Compare operand s with acc.
CPD	Compare location (HL) and acc. decrement HL and BC (CPDR; CPI; and CPIR are all compare commands)

EXCHANGE COMMANDS

EX(SP),HL	Exchange locations (SP) and HL
EX(SP),IX	Exchange locations (SP) and IX
EX(SP),IY	Exchange locations (SP) and IY (EX AF, AF'; EX DE, HL; and EXX are all exchange commands)

Instruction Set — Z-80

(Continued)

INCREMENT AND DECREMENT COMMANDS

INC (HL)	Increment location HL
INC IX	Increment IX
INC (IX+d)	Increment location (IX+d) (INC IY; INC(IY+d); INCr; and INCss are all increment commands)
DECm	Decrement operand m
DEC IX	Decrement IX
DEC IY	Decrement IY
DECss	Decrement reg. pair ss

INPUT COMMANDS

IN A(n)	Load acc. with input from device n
IN r(c)	Load reg. r with input from device c
IND	Load location (HL) with input from port (C), decrement HL and B
INDR	Load location (HL)
INI	Load location (HL) with input from port (C) and increment HL and decrement B
INIR	Load location (HL) with input from port (C), increment HL and decrement B, repeat until B=0

INTERRUPT COMMANDS

EI	Enable interrupts
IM 0	Set interrupt mode 0
IM 1	Set interrupt mode 1
IM 2	Set interrupt mode 2
RETI	Return from interrupt
RETN	Return from nonmaskable interrupt
HALT	Wait for interrupt or reset

SET AND TEST COMMANDS

SET b,(HL)	Set bit b of location (HL)
BIT b,(HL)	Test bit b of location (HL) (SET b, (IX+d); SET b,(IY+d); and SET b,r are all set commands, and BIT b,(IX+d); BIT b(IY+d); and BIT b,r are all test commands)

ARITHMETIC AND OTHER COMMANDS

CCF	Complement carry flag
SCF	Set carry flag (C=1)
CPL	Complement acc. (1's complement)
NEG	Negate acc. (2's complement)
NOP	No operation
SBC A,s	Subtract operand s from acc. with carry
SBC HL,ss	Subtract reg. pair ss from HL with carry
SUB s	Subtract operand s from acc.
AND s	Logical AND of operand s and acc.
OR s	Logical OR of operand s and acc.
XOR s	Exclusive OR operand s and acc.

MICROPROCESSOR ARCHITECTURE
UNIT III

JOB SHEET #1 — WRITE AND RUN A MACHINE LANGUAGE DRIVER PROGRAM TO CHECK A READ/WRITE MEMORY (RAM) LOCATION

A. Tools and equipment

1. Apple microcomputer as selected by instructor
2. Second microcomputer as selected by instructor
3. User's manual for each microcomputer
4. Pencil and paper

B. Procedure

(NOTE: The following procedures are for a 6502-based Apple microcomputer, but the procedure is general enough that it can be readily adapted for almost any 8-bit microprocessor.)

1. Check the user's manual for the safe procedure for turning the microcomputer ON and booting the system up
2. Turn the microcomputer ON and boot the system up as user manual directs
3. Make keyboard entries required to ready the microcomputer for machine language entries
4. Watch for the monitor signal that the microcomputer is ready for machine language entries

   (NOTE: On an Apple microcomputer an asterisk will appear when the microcomputer is ready for machine language entries.)

5. Make the following one-line entry in hexadecimal:

   (NOTE: Remember, with the Apple, the asterisk will already be on the screen, so make only the hexadecimal entries.)

```
* 300  A9  00  85  00  C5  00  D0  0B  A9  FF  85  00
```

6. Make the second one-line entry in hexadecimal:

```
* 30C  C5  00  D0  03  4C  69  FF  20  F0  FD  E
```

JOB SHEET #1

7. Conclude program by typing:

   300L

8. Press the RETURN key to execute the program

9. Check the monitor to make sure the program is displayed in assembly codes

   (NOTE: Refer to the Driver Program that accompanies this job sheet for the machine and assembly codes and the instructions for the program.)

10. Compare the machine codes and assembly codes and what happens as the program moves through the routine of checking and comparing 0's and 1's

11. Write down the machine codes and assembly codes and compare them

12. Show your list of comparisons to your instructor and discuss the procedure with your instructor

13. Turn the Apple microcomputer OFF and unplug the system

14. Plug the second microcomputer system in, turn it ON as the user's manual directs, and follow instructions for preparing the system to accept machine language entries

15. Repeat the driver program for the second system, and be sure to ask your instructor for help if you have questions about what hexadecimal entries you should make

16. Complete the program and make notes as the program moves through the routine of checking and comparing 0's and 1's

17. Show your list of comparisons to your instructor and discuss the procedure with your instructor

18. Turn microcomputer OFF and unplug the system

19. Clean up area and return tools and equipment to proper storage

JOB SHEET #1

6502 Driver Program

Language		
Machine	Assembly	Instruction
A9 00	LDA $00	Load the accumulator with only 0's
85 00	STA, Z $00	Store only 0's in zero page location $00
C5 00	CMP, Z $00	Compare accumulator with zero page location $00 (contents)
D0 0B	BNE $0B	Branch to error subroutine "E"
A9 FF	LDA $FF	Load the accumulator with only 1's
85 00	STA, Z 00	Store only 1's in zero page location $00
C5 00	CMP, Z 00	Compare accumulator with zero page location $00 (contents)
D0 03	BNE $03	Branch to error subroutine "E"
4C 69	JMP $FF69	Jump to monitor
FF 20	JSR $FDF0	Jump to subroutine display "E"
F0 FE		
E	$E	Data to be displayed

MICROPROCESSOR ARCHITECTURE
UNIT III

JOB SHEET #2 — WRITE AND RUN A DRIVER PROGRAM FOR MAKING EXPANDED READ/WRITE MEMORY (RAM) CHECKS

A. Tools and equipment

1. Apple microcomputer as selected by instructor
2. Second microcomputer as selected by instructor
3. User's manual for each microcomputer
4. Pencil and paper
5. Job Sheet #1

B. Procedure

(NOTE: The following procedure is for a 6502-based Apple microcomputer, but the procedure is general enough that it can be readily adapted for almost any 8-bit microprocessor.)

1. Hook up Apple microcomputer system, turn the microcomputer ON, and boot the system up
2. Prepare the system for machine language entries
3. Make the same machine language entries listed in Job Sheet #1
4. Load the total length of memory into any register that can be indexed

   (NOTE: Check with your instructor for the codes required for indexing.)
5. Execute the program and watch how the memory locations are checked and then indexed until all memories have been checked and validated or until an error occurs
6. Make notes of the order in which memory is checked
7. Discuss the procedure with your instructor and have the instructor check your notes
8. Run the program again if an error occurred so that the malfunctioning memory can be identified
9. Shut the Apple system down and repeat the procedure on a second system

JOB SHEET #2

10. Have your instructor check your work

    (NOTE: Your instructor may direct you to work with indirect indexing in order to permit the entire memory to be checked, so continue as directed.)

11. Turn microcomputer OFF and unplug the system from its power source

12. Clean up area and return tools and equipment to proper storage

MICROPROCESSOR ARCHITECTURE AND TIMING
UNIT III

NAME ______________________

TEST

1. Match the terms and symbols on the right with their correct definitions.

______a. A waveform in which the two halves appear to be approximately the same shape

______b. The time it takes for a waveform to rise from 10% of total amplitude to 90% of total amplitude

______c. The time it takes for a waveform to fall from 90% total amplitude to 10% total amplitude

______d. That time at which a waveform has passed a point in rise time to reach a functioning logic level of high

______e. That time at which a waveform has passed a point in fall time to reach a functioning logic level of low

______f. The symbol and number used to reference the phase one clock or the memory addressing phase of the clock function

______g. The symbol and number used to reference the phase two clock or the addressing and data phase of the clock function

______h. Symbol used to indicate a hexadecimal

1. Fall time
2. $\phi 1$
3. $
4. Symmetrical
5. Qualified low
6. Rise time
7. $\phi 2$
8. Qualified high

2. Differentiate between major elements of microprocessor architecture by placing an "X" beside the definition of internal architecture.

______a. The architecture that controls operations of the microprocessor through hardware including registers, encoders, decoders, and busses

______b. The architecture that connects the key parts of the system, the microprocessor, the memories, and the I/O's, through some kind of common bus structure

TEST

3. Complete the following statements concerning architecture of the 6502 microprocessor by inserting the word(s) that best completes each statement.

   a. An ____________ microprocessor both internally and externally

   b. Programmer accessible registers:

      1) The ____________

      2) The ____________ pointer

      3) Index register ____________

      4) Index register ____________

      5) Program ____________

      6) Status register with 7 ____________

   c. Flag functions:

      1) ____________ flag

      2) ____________ flag

      3) ____________ flag

      4) ____________ flag

      5) Special flags:

         a) An ____________ mask

         b) A break flag that indicates when ____________ has halted the system

         c) A ____________ flag for putting arithmetic operations into decimal mode

   d. Hidden registers — Include an ____________ register and I/O data latches

4. Select true statements concerning electrical characteristics of the 6502 by placing an "X" in the appropriate blanks.

   _____a. Uses a +12V power supply

   _____b. Is manufactured in versions ranging from 1 MHz to a high-speed 10 MHz version which other 8-bit microprocessors do not have

   _____c. System clock is on board the 6502 chip

TEST

5. Complete the following statements concerning architectural features of the 6502 by inserting the word(s) that best completes each statement.

    a. Has a unique system of internal data busses that allow for high speed direct and indirect addressing, and this is an ____________ feature of the 6502

    b. The program counter will generate a 16-bit address although it is actually done by ____________ ____________ program counters

    c. Has 3 ____________ interrupts:

        1) $\overline{\text{IRQ}}$

        2) $\overline{\text{NMI}}$

        3) $\overline{\text{RES}}$ or $\overline{\text{RST}}$

    d. Has ____________ instructions in its instruction set

    e. Has 13 addressing modes which include pre- and post-index indirect addressing, and this is a ____________ ____________ of the 6502

6. Complete the following statements concerning architecture of the 8080A microprocessor by inserting the word(s) that best completes each statement.

    a. An ____________ microprocessor both internally and externally

    b. ____________ accessible registers common to most of the other 8-bit microprocessors

    c. Special registers ____________ ____________ to other microprocessors

        1) One accumulator which is a single 8-bit register and referred to as "the" accumulator

        2) Six secondary registers that can be used to do internal data manipulations, and these registers are labeled: B, C, DE, and HL

        3) These special 8-bit registers can be paired internally so that two together can perform 16-bit arithmetic or logic operations

        4) Although loading the 8-bit registers still requires working through the 8-bit data bus, loading is not faster, but the paired function for logic and arithmetic is much faster

    d. In addition to the "A" register and the secondary registers there are:

        1) A 16-bit ____________ pointer

        2) A 16-bit ____________ pointer

        3) An 8-bit ____________ register which uses only 5 bits for flags

TEST

e. Another special feature of the 8080A is the temporary ____________ that works with the ALU much like an accumulator does to feed into the paired registers via another pair of hidden registers labeled the W and Z registers

f. Another 8080A feature is the special ____________ and ________ _____ latch ahead of the buffers which is used as an output for the 16-bit address

7. Select true statements concerning electrical characteristics of the 8080A by placing an "X" in the appropriate blanks.

(NOTE: For a statement to be true, all parts of the statement must be true.)

_____a. Uses four power supply voltages, +12V, -12V, +5V, and -5V

_____b. System clock is external to the 8080A chip and requires at least two other microprocessor support IC's:

1) An 8224 clock driver and generator

2) An 8228 systems controller and bus driver

_____c. The 8224 chip contains:

1) The oscillator which receives the external crystal signals for timing

2) A clock generator which takes the oscillator signal and creates the $\phi 1$ and $\phi 2$ outputs

3) The reset input for the system

4) Some control logic for internal purposes

_____d. The 8228 chip contains:

1) A bidirectional bus driver

2) A status latch for sending information from the 8080A to the outside system control bus

8. Complete the following statements concerning architectural features of the 8080A by inserting the word(s) that best completes each statement.

a. Has only one interrupt labeled ____________

b. Uses a ____________ ____________ signal to tell the microprocessor when to pass information through the bus to the microprocessor and when to wait

c. Has ____________ instructions in its instruction set

d. Has only ____________ addressing modes

TEST

9. Complete comparisons between the 8080A and the 8085 microprocessors by inserting the word(s) that best completes each statement.

   a. Knowing the architecture of the 8080A will make it much easier to understand the architecture of the 8085 because of their ____________ differences

   b. The major difference between the two is that the 8085 requires only one +5V power supply while the 8080A requires ____________ different voltages

   c. Another important different is that the 8085 has two extra functions to deal exclusively with serial I/O, and these pins are identified as:

      1) ____

      2) ____

   d. Another important difference is that the 8085 does not require the 8224 and 8228 external chips to support the clock because the clock is ____________

   e. Another difference is that the 8080A has a single interrupt while the 8085 has additional interrupts available with ____________ and ____________ instructions

   f. The 8085 also has ____________ address lines

10. Complete the following statements concerning architecture of the Z-80 microprocessor by inserting the word(s) that best completes each statement.

    a. An ____________ microprocessor both internally and externally

    b. Programmer accessible registers ____________ to most of the other 8-bit microprocessors

    c. The Z-80 has all of the main registers found in the 8080A plus an alternate set of registers that duplicates the main register set so that there are:

       1) ____________ "A" accumulators

       2) ____________ flag registers

       3) ____________ secondary registers

    d. Since there needs to be a way to clearly identify the alternate set of registers, they are referred to as:

       1) ____________ accumulator

       2) ____________ accumulator

       3) ____________ accumulator

       4) DE' accumulator

       5) HL' accumulator

TEST

e. The Z-80 also has the following 16-bit registers:

   1) An index register marked ____________

   2) A second index register marked ____________

   3) A ____________ pointer

   4) A ____________ counter

11. Select true statements concerning features that enhance Z-80 performance by placing an "X" in the appropriate blanks.

    (NOTE: For a statement to be true, all parts of the statement must be true.)

    _____a. The double registers in the Z-80 provide six 16-bit registers for use inside the microprocessor, and since a faster clock speed is another Z-80 enhancement, it means that the Z-80 can perform number crunching much faster than earlier model 8-bit microprocessors

    _____b. The two 16-bit index registers IX and IY give the Z-80 high speed and wide-ranging indexing capability

    _____c. The Z-80 has an 8-bit vector interrupt register to increase the interrupt capability

12. Complete the following statements concerning electrical characteristics of the Z-80 by inserting the word(s) that best completes each statement.

    a. Uses one ____________ power supply

    b. System clock is ____________ the Z-80 chip

13. Select true statements concerning architectural features of the Z-80 by placing an "X" in the appropriate blanks.

    (NOTE: For a statement to be true, all parts of the statement must be true.)

    _____a. Has 78 instructions in its instruction set

    _____b. Encompasses the 8080A instruction set, and enhances it with instructions broken into the following instruction blocks:

       1) 8-bit loads and 16-bit loads

       2) 16-bit

       3) Exchanges, block transfers, and searches

       4) 8-bit arithmetic and logic operations

       5) General purpose arithmetic and microprocessor control

TEST

6) 16-bit arithmetic

7) Rotates and shifts

8) Bit set, reset, and testing

9) Jumps

10) Subroutine calls, returns, and I/O operations

_____c. Has 9 addressing modes

14. Complete the following statements concerning the architecture of the 6800 microprocessor by inserting the word(s) that best completes each statement.

a. An ____________ microprocessor both internally and externally

b. Program accessible registers:

1) Accumulator ____________

2) Accumulator ____________

3) A ____________ index register marked IX

4) A ____________ program counter

5) A ____________ stack pointer

6) Condition code ____________ with 6 flags

c. Condition code functions:

1) ____________ flag

2) ____________ ____________ flag

3) Zero flag

4) Sign flag

5) ____________ flag

6) Interrupt mask flag

15. Select true statements concerning electrical characteristics of the 6800 by placing an "X" in the appropriate blanks.

_____a. Uses a single +12V power supply

_____b. Requires an external clock generator such as the MC6871 or the MC6875

TEST

16. Select true statements concerning architectural features of the 6800 by placing an "X" in the appropriate blanks.

(NOTE: For a statement to be true, all parts of the statement must be true.)

______a. Hidden registers include the instruction register, I/O data latch, address buffers and latches, and ALU

______b. Has a bidirectional data bus

______c. Although it is a 16-bit microprocessor both internally and externally, it functions as 8-bits part of the time

______d. Has three vectored interrupts

1) $\overline{IRQ}$

2) $\overline{NMI}$

3) $\overline{RES}$ or $\overline{RST}$

______e. Has 56 instructions in its instruction set

______f. Has seven addressing modes

17. Complete comparisons of the 6800 and 6802 microprocessors by inserting the word(s) that best completes each statement.

a. Knowing the architecture of the 6800 will make it much easier to understand the architecture of the 6802 because of their ____________ similarities

b. The 6802 architecture varies from the 6800 in only two ways:

1) The clock is ____________ the 6802 so an extra ____________ is ____________

2) 128 bytes of on board RAM have been added with a ____________ power source to retain 32 bytes even after power is turned off, and the remaining serves as additional RAM

18. Complete the following statements concerning the architecture of the 8088 microprocessor by inserting the word(s) that best completes each statement.

a. A ____________ microprocessor internally but is specifically designed to behave like an ____________ microprocessor

TEST

b. Programmer addressable registers are broken down into three major groups of four registers each and one additional group of single-purpose registers:

1) ____________ group registers:

a) Accumulator

b) Base

c) Count

d) Data

2) ____________ and ____________ group registers:

a) Stack pointer

b) Base pointer

c) Source index

d) Destination index

3) ____________ registers

4) ____________ ____________ registers:

a) 16-bit instruction pointer

b) 16-bit flag register

19. Select true statements concerning characteristics of the 8088 group registers by placing an "X" in the appropriate blanks.

_____a. Data group registers are not limited to traditional register functions as their names might indicate because they all serve multiple functions

_____b. Data group registers are designed to act as a subset of 8-bit registers that will mimic the true 8-bit operations of the 8080 and 8085 microprocessors

_____c. Pointer and index group registers have traditional functions with arithmetic and logic

_____d. Pointer and index group registers also have powerful features such as instructions that multiply and divide, perform string operations, and access large amounts of memory in the index mode by using the 8088's unique address segmentation technique

_____e. Segment registers are used to create offsets within the entire span of the 64K memory blocks to allow the addressing of multiple 64K byte segments of memory so that a programmer literally has available up to 1 megabyte of memory

TEST

_____f. The single-purpose registers serve traditional functions because the 16-bit instruction pointer is the same as a program counter, and the 16-bit flag register dedicates its lower 8 bits to the same flag functions found in the 8080A or 8085

20. Select true statements concerning the 8088 instruction set by placing an "X" in the appropriate blanks.

_____a. Compared to the instruction sets for the 6502 and 6800, the instruction set for the 8088 would have to be considered simple

_____b. In machine language, the 8088 instruction set has approximately 30 instructions

_____c. In assembly language, the 8088 instruction set has approximately 10 instructions

21. Complete the following statements concerning the significance of timing functions by inserting the word(s) that best completes each statement.

a. Timing manages the ____________ activity within a microcomputer system, and the electrical pulses that constitute timing signals produce waveforms that can be screened on an oscilloscope and evaluated

b. For a waveform to rise from zero to peak value takes a certain amount of time, and to fall from peak value to zero takes a certain amount of time, and these ____________ and ____________ times are critical to timing

c. There is a short time delay between the time that $\phi 1$ clock becomes qualified high and the time that $\phi 2$ clock becomes qualified low, and this short time delay is to insure that the two waveforms ____________ ____________ ____________

22. Solve the following problems concerning waveform interpretations.

a. A fellow troubleshooter has just hooked up an oscilloscope and made a reading of a waveform on a 6502 microprocessor. Your friend announces that the waveform is not right and that the microprocessor is bad and should be replaced.

Solution ____

____

b. A fellow troubleshooter complains that the oscilloscope will not screen a waveform that looks like the waveform presented in the schematic

Solution ____

____

TEST

23. Complete the following list of other signals related to clock timing by inserting the word(s) that best completes each statement.

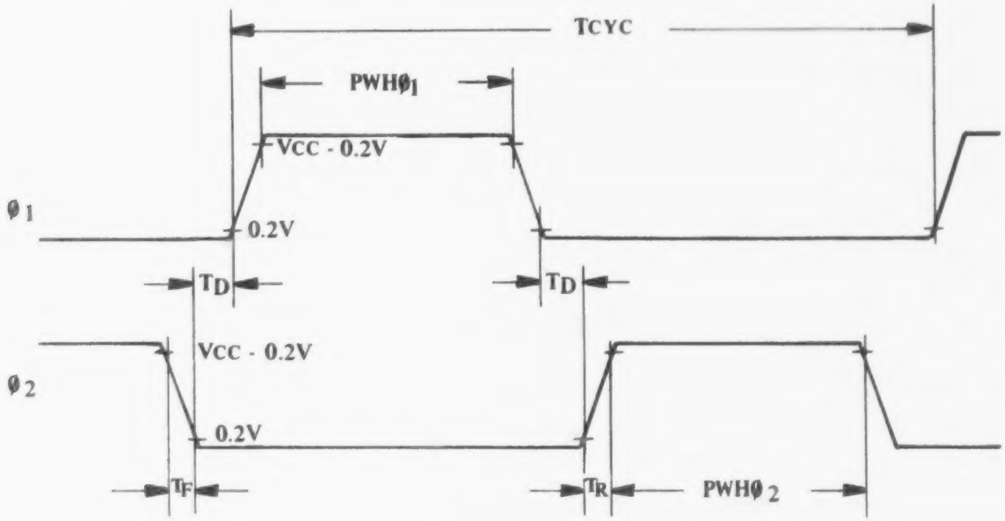
    a. ____________/____________ signals

    b. What occurs on the ____________ and ____________ busses with respect to ____________

24. Interpret the following line diagram of the 6502 clock timing by completing the following statements.

    a. Clock phases are symmetrical but opposite so that when $\phi 1$ clock signal is high, $\phi 2$ clock signal is ____________

    b. The high going signals of both clock phases are ____________ than the low going signals



TEST

25. Interpret the following typical 6500/6800 cycle for reading data from memory to peripherals by completing the following statements.

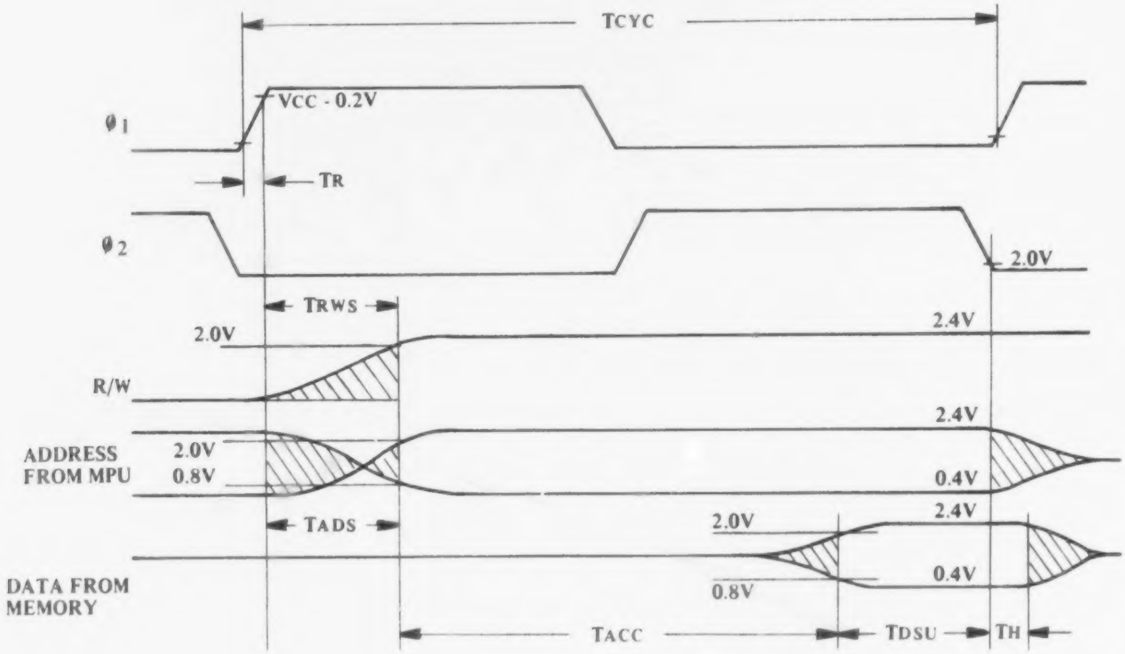
    a. With respect to $\phi 1$ clock, the read/write line changes when the $\phi 1$ clock goes to ______________ ______________

    b. The letters ______________ indicate read/write setup time

    c. The letters ______________ indicate time for address setup

    d. The diagram indicates that read/write setup and address setup takes place ______________

    e. The critical time that data is actually available from the memory to the bus is indicated by the letters ______________


TCYC
VCC - 0.2V
φ1
TR
φ2
2.0V
TRWS
2.0V
2.4V
R/W
2.4V
ADDRESS FROM MPU
2.0V
0.8V
0.4V
TADS
2.0V
2.4V
DATA FROM MEMORY
0.8V
0.4V
TACC
TDSU
TH

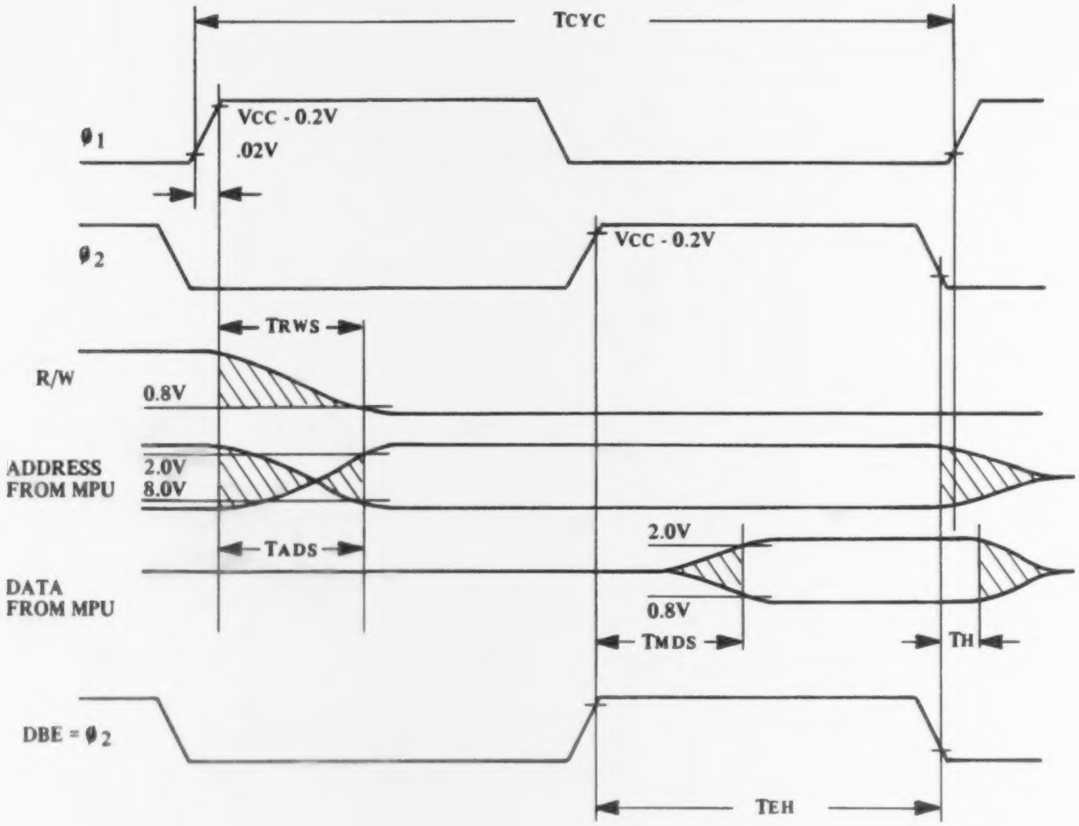
TEST

26. Interpret the following typical 6500/6800 cycle for writing data to memory or peripherals by completing the following statements.

    a. Waveforms for writing data look like ____________ ____________ ____________ ____________

    b. When writing from the microprocessor to memory or to peripherals, the ____________ clock must be ____________

    c. The DBE means data bus enable and is a signal that must be ____________ for data bus transfer to occur


TCYC
φ1
VCC - 0.2V
.02V
φ2
VCC - 0.2V
TRWS
R/W
0.8V
ADDRESS FROM MPU
2.0V
8.0V
TADS
2.0V
DATA FROM MPU
0.8V
TMDS
TH
DBE = φ2
TEH

TEST

27. Complete the following statements concerning instruction sets by inserting the word(s) that best completes each statement.

    a. Instruction sets consist of codes that a microprocessor will ____________ so that it can perform a specific programmed activity

    b. Instruction sets are handy for a troubleshooter because they can be used to write ____________ programs that will operate a component that needs evaluation

    c. Instruction sets are grouped into general categories according to their functions:

        1) Instructions that ____________ data

        2) Instructions that perform ____________ and ____________ functions

        3) Instructions that make ____________

        4) Instructions that perform ____________ register transfer

        5) Instructions that perform single ____________ operations

        6) Instructions that perform ____________ operations

28. Select true statements concerning instructions that move data by placing an "X" in the appropriate blanks.

    _____a. The movement of data is usually the last part of an instruction set because the movement of data is critical to the entire system operations

    _____b. None of the operations normally performed by a microprocessor can be performed without data, so instructions that move data are used almost as much as instructions for internal operations

29. Select true statements concerning instructions for internal transfer by placing an "X" in the appropriate blanks.

    _____a. Instructions for internal transfer move data and, sometimes, address information from one register or temporary storage location inside the microprocessor to another location outside the microprocessor

    _____b. Internal transfer instructions all take place inside or close to inside the microprocessor itself and because of this, these operations have to be exact and usually are relatively slow

30. Complete the following statements concerning instructions for arithmetic and logic functions by inserting the word(s) that best completes each statement.

    a. In most cases, the reason for bringing information into a microprocessor is for the microprocessor to perform an arithmetic or logical function with the information and for that reason arithmetic and logic operations are the ____________ functions of a microprocessor

TEST

b. When it performs logical functions, the microprocessor works like a ____________ ____________ in performing AND, OR, and EOR operations

c. When it performs arithmetic functions, the typical 8-bit microprocessor can only ____________ and ____________, and even then the ALU is mostly an adder and must complete a 2's complement of one of the numbers to be added in order to perform subtraction

d. In most cases, logical shifting of the data word is used in ____________ and ____________ with the adder-type microprocessor, so shift instructions make it possible to ____________ and ____________ efficiently

31. Complete the following statements concerning instructions for decision making by inserting the word(s) that best completes each statement.

a. Instructions for decision making follow movement, internal transfer, and arithmetic/logic operations because this is the point where a decision must be made concerning the information that has been ____________ ____________

b. Decision making is based on the status of the ____________ operation that was performed by the ____________ instruction

c. The status is reflected in "status bits" which are normally referred to as ____________ and decision making is based on the presence of the ____________ "high" or the absence of the ____________ "low"

d. In almost all 8-bit microprocessors, high flag is represented by logic ____________ and low flag represented by logic ____________

e. In almost all 8-bit microprocessors, there are three basic flags:

  1) ____________ flag

  2) Algebraic ____________ flag

  3) ____________ flag

f. A variation of decision making found in many microprocessors permits a facility to move to a location other than the next location in a program and this involves:

  1) ____________ or making a decision as to how far to go

  2) ____________ or making a decision to go to a specific address location

g. There are two types of jumps:

  1) ____________, which refers back to decision making because a decision may be involved in whether or not to jump

TEST

2) _____________, which means the program will jump to a new location without a decision, and in turn, the unconditional jump may be:

   a) _____________, which means the program will not return to the place it jumped from

   b) Jump to _____________, which means the program will perform the _____________ and then return to the place in the program that it jumped from

h. _____________ and _____________ jumps have one thing in common in that they can move the program counter, and these are usually the only kinds of instructions that can move the program counter

32. Select true statements concerning instructions for comparison by placing an "X" in the appropriate blanks.

______a. Instructions for comparison in most 8-bit microprocessors are variations of normal subtraction activity that takes place in the ALU

______b. In a comparison instruction, the binary number to be compared is placed into the accumulator and is compared with another number by subtracting the second number from the number placed in the accumulator

______c. In a comparison instruction, the result is not stored in the accumulator, rather, the result is discarded and the results of the comparison are indicated by the status flag

33. Complete the following statements concerning instructions for indexing by inserting the word(s) that best completes each statement.

a. Instructions for indexing are used frequently in two types of program operations:

   1) _____________, where the index is a number set into a register or memory location to cause the program to repeat a certain operation a given number of times

   2) _____________ _____________, where the index is used for table loading or table storage

b. Index literally means to change register contents by one in either direction, subtract one from a location or add one to a location

   1) Subtracting is called "_____________" the index

   2) Adding is called "_____________" the index

c. In several 8-bit microprocessors, there are specific _____________ registers that are either 8-bits long or double length, 16-bits long

TEST

34. Select true statements concerning instructions for internal operations by placing an "X" in the appropriate blanks.

    ______a. Instructions for internal operations vary among microprocessors because in each microprocessor there is a unique set of internal registers

    ______b. To deal with an internal register set requires special internal instructions which in some cases may designate a specific bit location inside a register

    ______c. Although they may have impact on only internal parts of a microcomputer, stack operations are considered to be external in nature

    ______d. The stack is simply a location in memory where the contents of an internal register can be kept when it is necessary to temporarily save them

35. Complete the following statements concerning instructions for special operations by inserting the word(s) that best completes each statement.

    a. Instructions for special occasions vary among microprocessors because in most microprocessors there are a few instructions ____________ to a particular microprocessor and they do not fit neatly into any group or block

    b. Other special instructions are so termed because of the ____________ they serve although they may or may not be unique to a given system

36. Complete the following statements concerning addressing modes by inserting the word(s) that best completes each statement.

    a. Addressing modes provide the ____________ to use an instruction with more than one type of register or memory

    b. Instructions for performing some general operation do not have to be rewritten for each register, and this saves time and provides ____________

37. Match addressing modes with their characteristics.

    ______a. An addressing mode in which the instruction is completely self-contained in the OPCODE and there is no data or addressing required for the instruction to know where to go and what type of operation to perform

    ______b. An addressing mode in which the instruction OPCODE is followed immediately by an 8-bit data word which is operated on by the instruction, and the address of the data is understood to be the next immediate location in memory

    ______c. An addressing mode in which data is given in a full 16-bit address following the instruction OPCODE and the instruction operates on the 16-bit address

    1. Indexed
    2. Relative
    3. Implied or inherent
    4. Absolute or extended
    5. Indirect
    6. Immediate
    7. Zero page
    8. Direct

TEST

______d. An addressing mode which allows performance of some instruction indicated by the OPCODE on an address that is relative to some location; usually that location is the current location of the program counter

______e. An addressing mode in which the location that the instruction OPCODE will operate on is dependent on the contents of the index specified in the instruction and allow a programmer to create very short blocks of code that will store or evaluate long tables of information

______f. An addressing mode in which the address that follows the instruction OPCODE is the address of an address so that an indirect instruction means the OPCODE must first go to the location only given by the program to find the address of the data to be operated on

______g. An addressing mode in which part of the instruction details the way the address is found during an instruction cycle

______h. An addressing mode where one and only one byte of code follows the OPCODE to indicate an address found in this page of memory

38. Complete the following statements concerning interrupts and how they work by inserting the word(s) that best completes each statement.

a. An interrupt is a signal that will cause a microprocessor to stop what it is doing and perform some other ____________ ____________ operation

b. Almost all 8-bit microprocessors have interrupt functions in order to deal with outside world functions that operate in ____________ time

c. An interrupt permits the microprocessor to ____________ ____________ economically while interacting with outside world input

d. An interrupt permits external ____________ input into the microprocessor so it can be used for multiple purposes

TEST

39. Differentiate between types of interrupts by placing an "X" beside the definition of a request interrupt.

    _____a. An interrupt with a nonemergency priority so that the interrupt signal will get the microprocessor's attention but not be executed until the microprocessor has finished the operation with which it is currently working

    _____b. An interrupt with an emergency priority that signals the microprocessor to stop instantly what it is doing and accept interrupt instructions

40. Complete the following statements concerning the OPCODE and operands by inserting the word(s) that best completes each statement.

    a. Each 8-bit microprocessor has only ____________ unique binary numbers that may be specified by an 8-bit binary word, and these unique numbers are called OPCODES

    b. An OPCODE tells the microprocessor the ____________ of the operation of be performed, what ____________ to set up, and even the ____________ involved in each program step

    c. Other instructions, operands, follow the OPCODE, and these instructions are ____________ according to program needs, but OPCODES are ____________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

41. Demonstrate the ability to:

    a. Write and run a machine language driver program to check a read/write memory (RAM) location. (Job Sheet #1)

    b. Write and run a driver program for making expanded read/write memory (RAM) checks. (Job Sheet #2)

MICROPROCESSOR ARCHITECTURE AND TIMING
UNIT III

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 1
   d. 8
   e. 5
   f. 2
   g. 7
   h. 3

2. a

3. a. 8-bit
   b. 1) Accumulator
      2) Stack
      3) X
      4) Y
      5) Counter
      6) Flags
   c. 1) Zero
      2) Carry
      3) Sign
      4) Overflow
      5) a) Interrupt
         b) Software
         c) Decimal
   d. Instruction

4. b,c

5. a. Outstanding
   b. Two 8-bit
   c. Vectored
   d. 56
   e. Special feature

6. a. 8-bit
   b. Programmer
   c. Not common
   d. 1) Stack
      2) Program
      3) Flag
   e. Multiplexer
   f. Incrementer, decrementer

7. b,c,d

8. a. $\overline{INT}$
   b. Bus enable
   c. 78
   d. Four

ANSWERS TO TEST

9. a. Major
   b. Three
   c. 1) SID
      2) SOD
   d. Internal
   e. RIM, SIM
   f. Multiplexed

10. a. 8-bit
    b. Common
    c. 1) Two
       2) Two
       3) Twelve
    d. 1) A'
       2) B'
       3) C'
    e. 1) IX
       2) IY
       3) Stack
       4) Program

11. a,b,c

12. a. +5V
    b. On

13. b,c

14. a. 8-bit
    b. 1) A
       2) B
       3) 16-bit
       4) 16-bit
       5) 16-bit
       6) Register
    c. 1) Carry
       2) Half-carry
       5) Overflow

15. b

16. a,b,d,f

17. a. Basic
    b. 1) On, component, eliminated
       2) Battery

ANSWERS TO TEST

18. a. 16-bit, 8-bit
    b. 1) Data
       2) Pointer, index
       3) Segment
       4) Single-purpose

19. a,b,c,d,e,f

20. None of the statements are true

21. a. Orderly
    b. Rise, fall
    c. Do not overlap

22. a. Reevaluate the waveform and never hastily evaluate an oscilloscope waveform
    b. The oscilloscope waveform and the diagrammed waveform have to be properly equated because they frequently don't look alike

23. a. Read/write
    b. Address, data, memory

24. a. Low
    b. Shorter

25. a. Qualified high
    b. TRWS
    c. TADS
    d. Simultaneously
    e. TDSU

26. a. Waveforms for reading data
    b. $\phi 2$, high
    c. High

27. a. Recognize
    b. Driver
    c. 1) Move
       2) Arithmetic, logical
       3) Decisions
       4) Internal
       5) Byte
       6) Miscellaneous

28. Neither statement is true

29. Neither statement is true

30. a. Major
    b. Logic gate
    c. Add, subtract
    d. Multiplying, dividing, multiply, divide

31. a. Acted upon
    b. Last, previous
    c. Flags, flag, flag
    d. 1,0

ANSWERS TO TEST

- e.
  - 1) Zero
  - 2) Sign
  - 3) Carry
- f.
  - 1) Branching
  - 2) Jumping
- g.
  - 1) Conditional
  - 2) Unconditional
    - a) Ordinary
    - b) Subroutine, subroutine
- h. Conditional, unconditional

32. a,b,c

33. a.
    - 1) Counting
    - 2) Table operations
    - b.
    - 1) Decrementing
    - 2) Incrementing
    - c. Index

34. a,b,d

35. a. Unique
    b. Purposes

36. a. Freedom
    b. Flexibility

37. a. 3
    b. 6
    c. 4
    d. 2
    e. 1
    f. 5
    g. 8
    h. 7

38. a. Previously programmed
    b. Real
    c. Continue functioning
    d. Asynchronous

39. a

40. a. 256
    b. Nature, registers, addressing
    c. Generic, unique

41. Performance competencies evaluated according to procedures outlined in the job sheets

TOOLS AND TEST EQUIPMENT
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the hand tools and test instruments used for troubleshooting microcomputer systems, and discuss test instruments designed specifically for microcomputer troubleshooting. The student should also be able to use a DVOM, an oscilloscope, a frequency meter, and logic, pulsar, and current tracing probes to effectively check microcomputer electrical activity. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to tools and test equipment with their correct definitions.
2. Complete statements concerning standard hand tools for microcomputer repair.
3. Complete a list of special tools for handling IC's.
4. Solve problems concerning soldering equipment.
5. Complete statements concerning lubrication tools and materials.
6. Solve a problem concerning adhesives and sealant.
7. Complete a list of inspection and cleaning tools.
8. Solve problems concerning static control devices.
9. Select true statements concerning tool kits.
10. Complete statements concerning other specialty tools and equipment.

OBJECTIVE SHEET

11. Select true statements concerning power supplies.
12. Match electronic test instruments with their typical uses.
13. Match special test instruments with their characteristics.
14. Complete statements concerning DVOM operations.
15. Complete statements concerning oscilloscope operations.
16. Select true statements concerning data analyzer operations.
17. Select true statements concerning emulator operations.
18. Demonstrate the ability to:
    a. Use a DVOM to test a microcomputer system bus. (Job Sheet #1)
    b. Use an oscilloscope to check a microcomputer clock signal. (Job Sheet #2)
    c. Use a frequency meter to check the clock frequency on a microcomputer system bus. (Job Sheet #3)

TOOLS AND TEST EQUIPMENT
UNIT IV

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss unit and specific objectives.

D. Discuss information sheet.

E. Discuss and demonstrate the procedures outlined in the job sheets.

F. Invite a manufacturer's representative from a test instrument company to talk to the group about special equipment designed for working with microcomputer and peripherals, and have the representative demonstrate the instrument(s) to the class.

G. Have several supply catalogs available so the class can look at the many special tools and supplies such as lint-free swabs and anti-static cleaning sprays that are available for the service technician.

H. Demonstrate how a logic probe, a current tracer, and a logic pulser are used in microcomputer troubleshooting.

I. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

   1. Job Sheet #1 — Use a DVOM to Test a Microcomputer System Bus

   2. Job Sheet #2 — Use an Oscilloscope to Check a Microcomputer Clock Signal

   3. Job Sheet #3 — Use a Frequency Meter to Check the Clock Frequency on a Microcomputer System Bus

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *The IC Troubleshooters, New Techniques of Digital Troubleshooting, Applications Note 163-2.* Palo Alto, CA 94304: Hewlett-Packard, No date.

B. *A Designer's Guide to Signature Analysis, Applications Note 222.* Palo Alto, CA 94304: Hewlett-Packard, 1980.

C. *A Signature Analysis Case Study of a Z-80 Based Personal Computer, Application Note 222-10.* Palo Alto, CA 94304: Hewlett-Packard, 1980.

D. *Black Box Catalog of Data Communications and Computer Devices.* Pittsburg, PA 15241: Black Box Corporation, 1985.

E. *Computer Supplies Catalog.* Hartford, CT 06104: Wheeler Group, Inc., 1984.

F. *Jensen 1985 Spring Supplement, A Tool Buyer's Best Friend.* Phoenix, AZ 85040: Jensen Tools, Inc., 1985.

TOOLS AND TEST EQUIPMENT
UNIT IV

INFORMATION SHEET

I. **Terms and definitions**

A. DA — Data analysis, a procedure for evaluating activity on the data bus of a microcomputer

B. DVOM — Digital volt-ohm milliamp, a multirange test instrument popular in digital troubleshooting

C. SA — Signature analysis, a procedure for evaluating the unique signatures generated at single nodes within a microcomputer system and comparing those signatures with signatures made when the system was operating properly

D. Scope — An abbreviated reference to an oscilloscope

E. Signature — The unique hexadecimal composition of any data mode in a microcomputer circuit under test

II. **Standard hand tools for microcomputer repair**

A. Assorted flatblade and Phillips screwdrivers for general disassembly and assembly

B. Jewelers screwdriver set for interior work on printers, disk drives, and microcomputers

C. Nutdriver set from 3/16" to 1/2" for general disassembly and assembly

D. Hex (hexagonal) wrenches from 1/16" to 1/4" for general repair work

E. Combination open-end box-end wrenches from 3/16" to 1/2" for general repair work

F. File set containing both round and flat files for general work

G. Standard slip joint pliers, 4" to 4 1/2" for holding

H. Needlenose pliers for hard-to-get places

I. Flat, duckbill-type pliers for parts holding

J. Diagonal cutting pliers for work on PC boards

K. Reversible snap-ring pliers for removing and replacing snap-rings

L. Wire strippers for cable makeup

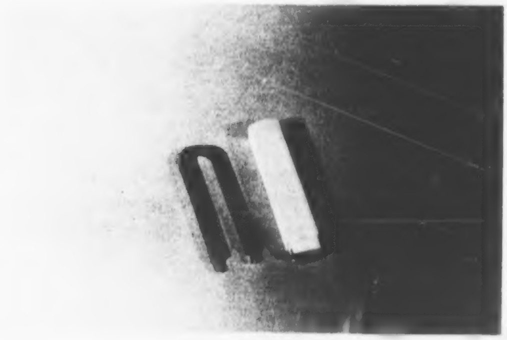
M. Small hammer with lucite head for tapping parts together

INFORMATION SHEET

III. **Special tools for handling IC's**

   A. Chip extractor and inserter (Figure 1)

   FIGURE 1



   B. Tweezers

   C. Hemostat (forceps)

   D. IC test clips

      1. 16-pin DIP test clip will work on both 14-pin and 16-pin IC's

      2. 28-pin DIP test clip will work on both 24-pin and 28-pin IC's

      3. 40-pin DIP test clip is used to test microprocessors

IV. **Soldering equipment**

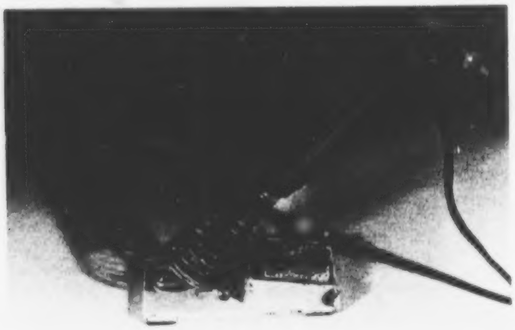
   A. Soldering iron for PC board work, 25 to 60 watts

   B. Soldering iron for chassis work, 60 watts

INFORMATION SHEET

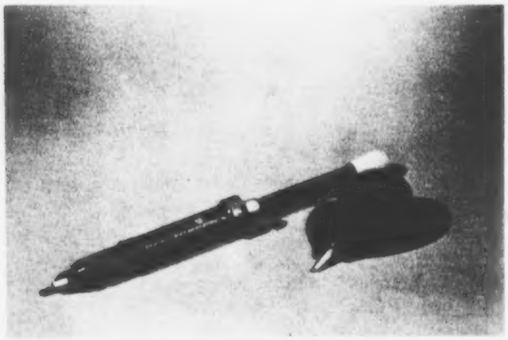
C. Soldering iron stand or station (Figure 2)

FIGURE 2



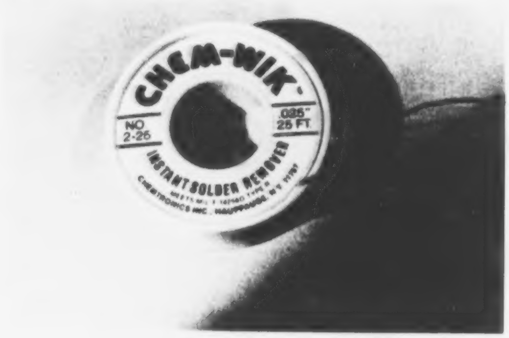
D. Desoldering tool, preferably a piston-loaded type that will pull solder up quickly from sockets and connections (anti-static type) (Figure 3)

FIGURE 3



E. Desoldering wick for pulling solder off flat surfaces, especially PC boards (Figure 4)

FIGURE 4


CHEM-WIK
NO 2-25
.025" 25 FT.
INSTANT SOLDER REMOVER

INFORMATION SHEET

F. Cleaning sponge for soldering tip

G. Supply of resin-cored solder in both large (.062") and small (.031") diameters

(CAUTION: Only resin-cored solder should be used in microcomputer and peripheral repair, and good solder will be so marked and probably indicate its tin/lead content as 63/37 alloy, or 63% tin and 37% lead.)

V. **Lubrication tools and materials**

A. Plastic oiling bottles with leak-proof spouts are recommended for repair and maintenance service

B. High quality machine oil is used for some moving parts on both disk drives and printers

C. Teflon-based lubricants are specified for some printer and disk drive applications

D. Graphite-based lubricants are specified for some printer applications

E. Precision oilers are required for certain disk drive applications (Figure 5)

FIGURE 5

VI. **Adhesives and sealants**

A. Adhesives are used primarily on printers and disk drives, usually after reassembly when nuts or bolts subject to heavy wear or vibration are replaced

B. Adhesives should dry fast and hold securely, and OEM specifications for adhesives should always be followed

(NOTE: *Locktite* is one brand name of adhesive or sealant that is frequently used by repair technicians, and it meets most OEM specifications.)

C. Sealants should also meet OEM specifications

INFORMATION SHEET

VII. **Inspection and cleaning tools**

A. Small flashlight

B. Inspection mirror (dental-type)

C. Small brushes

D. Small battery operated DC vacuum cleaner

(NOTE: An AC vacuum cleaner can create magnetic fields that will erase memory.)

E. Spray can

VIII. **Static control devices**

A. Static control stations with static mats and wrist bands are ideal for work stations

(NOTE: For students just beginning to work with chip removal and replacement, static mats and wrist bands are considered mandatory.)

B. Chips removed from a board or chips to be replaced should always be kept on a piece of static foam to protect them at all times

C. An anti-static spray may be required in special circumstances, and it is always a good idea to have a can around, especially on service calls

D. An inexpensive static mat can be made by taping aluminum foil to a piece of cardboard (Figure 6)

FIGURE 6

INFORMATION SHEET

IX. **Tool kits**

A. Most service centers supply tool cases or kits for those technicians who troubleshoot and repair at a customer site

B. Some tool kits may be especially equipped for a specific type of installation, and when checking out a tool kit for use in the field, make sure you have the right one

(NOTE: A tool kit used specifically for printer repair will contain lubricants, adhesives, and other items that may not be needed for troubleshooting or repairing a microcomputer.)

X. **Other specialty tools and equipment**

A. Surge protectors for controlling spikes and transients are a must in the repair center and in the field

B. Cables and connectors are often required in repair activity

C. Shrink tubing and a heating gun to shrink it should both be available if needed

D. A set of X-Acto knives is handy for making up cables

E. A supply of miscellaneous clips, wires, and nuts and bolts will come in handy, and the technician will learn from experience the incidental supplies that make the job easier

XI. **Power supplies**

A. Additional power supplies should be available for troubleshooting microcomputer systems that require separate power supplies for driving add-ons and peripherals

B. A multi-range (0V to 25V) DC power supply will probably be needed often

C. A small 5V, high current power supply is also required for certain testing

XII. **Electronic test instruments and typical uses**

A. DVOM — Excellent instrument for troubleshooting power supplies and all kinds of power cables

INFORMATION SHEET

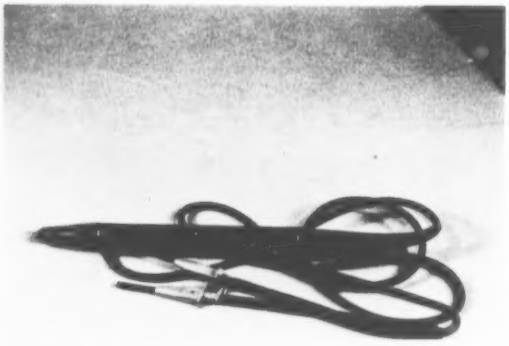
B. Osciiloscope — Only instrument that can provide a visual dual trace image for examining clock timing signals (Figure 7)

FIGURE 7

C. Frequency meter (counter) — Gives a quick, accurate reading of clock frequency and saves hooking up an oscilloscope

D. Probes — Logic probe is used essentially to check voltage, logic pulsar can check line activity when system is off, and current tracer is effective for finding grounds and shorts on PC boards (Figure 8)

FIGURE 8



INFORMATION SHEET

XIII. Special test instruments and their characteristics

A. Signature analyzer — An instrument that displays the electrical signatures unique to each data node so that a troubleshooter can compare working signatures with correct ones and isolate a faulty node

Example: The following table is from Hewlett-Packard's *Application Note 222-10* and shows the address bus signature table for a Z-80 microprocessor

ADDRESS	PIN	SIGNATURE	ADDRESS	PIN	SIGNATURE
A15	5	755U	A7	37	52F8
A14	4	3827	A6	36	UPFH
A13	3	3C96	A5	35	OAFA
A12	2	HAP7	A4	34	5H21
A11	1	1293	A3	33	7F7F
A10	40	HPP0	A2	32	CCCC
A9	39	2H70	A1	31	5555
A8	38	HC89	A0	30	UUUU

Courtesy Hewlett-Packard

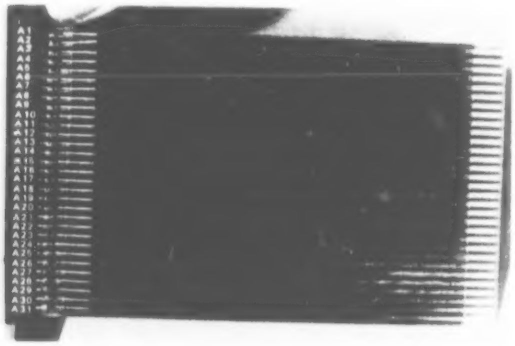
B. Data analyzer — A low-cost version of a signature analyzer that checks bus activity and does a good job isolating difficult problems related to software/hardware interaction

C. Floppy disk analyzer — A relatively expensive but effective instrument for checking speed, alignment, and general performance of a floppy disk drive

D. Emulator — A relatively expensive test instrument designed to replace and test the system microprocessor

E. Extender card — An inexpensive PC card that fits onto the system bus so that all signals on the bus are easily accessible for testing (Figure 9)

FIGURE 9



INFORMATION SHEET

XVI. **Data analyzer operations**

A. A data analyzer's primary function is to analyze the activity of the microcomputer data bus

B. The data analyzer is connected to the data bus, to timing signals, and to ground

C. Most data analyzers have a "recognizer probe" or module which allows a troubleshooter to recognize control conditions that are causing the problem

D. The data analyzer recreates the fault condition that is causing the problem and permits examination of the data stream before and after a fault so the trouble can be analyzed

E. Data analyzers are being used more and more in repair facilities because of their capability for quickly isolating the most troublesome microcomputer problems — hardware/software faults in combination

XVII. **Emulator operations**

A. An emulator is designed to replace a microprocessor in a microcomputer system to provide a method for testing and evaluating all microprocessor activities within the system

B. An emulator is designed to duplicate the functions of one specific microprocessor and will not work for any other microprocessor

(NOTE: An emulator has a cable connection that is physically placed into the PC board in place of the microprocessor chip.)

C. A micro system under test and running cannot tell that an emulator is in the circuit, so the emulator can change things under software control

D. With an emulator, a troubleshooter can reach into any point of a system to evaluate operations, or even store information for the troubleshooter to operate with

Example: A troubleshooter can use an emulator to change the contents of registers, or condition flags in response to system activity, and then evaluate microcomputer activity based on those changes

E. An emulator is an excellent troubleshooting tool, but to use it well, a troubleshooter needs a good background in the microcomputer system under test, and a good knowledge of the microprocessor and its machine language

TOOLS AND TEST EQUIPMENT
UNIT IV

JOB SHEET #1 — USE A DVOM TO TEST A MICROCOMPUTER SYSTEM BUS

A. Tools and materials

1. Microcomputer as selected by instructor
2. Service manual or Computerfacts® for microcomputer
3. DVOM and operator's manual
4. Extender card for system bus (if available)
5. Pencil and paper

B. Procedure

1. Identify the voltage points on the system bus, and make a chart of the voltages that should be present at each point
2. Set the DVOM for a DC function because the first measurements on the system bus will be the DC voltage
3. Set the range function for as close to 12V as possible

   (NOTE: Some meters will go as low as 20V, others may be 25V to 30V, so any range up to 30V is acceptable, but don't select an excessive range.)

4. Check function and range settings carefully, then make sure the black negative lead and the red positive lead are properly attached to the DVOM
5. Turn the DVOM ON
6. Turn the microcomputer ON
7. Place the black negative lead on a ground and measure the voltages at each of the check points previously selected
8. Record each reading in its appropriate place on your system bus voltage chart

   (NOTE: In the event you're using an instrument that does not have automatic polarity, your lead for measuring positive voltages should be black to ground, and for measuring negative voltages, red should be to ground.)

9. Have your instructor check your work

JOB SHEET #1

C. Procedure for checking resistance

1. Unplug the microcomputer

   (NOTE: Remember that the DVOM has its own voltage supply for measuring ohms, so you cannot measure circuit resistance with the AC power ON, and if attempted, it could damage both the DVOM and the micro system.)

2. Set the DVOM for an Ohm function in the lowest range

3. Turn the power switch of the microcomputer ON

   (NOTE: Although the microcomputer is unplugged from its AC power source, the system switch itself must be ON.)

4. Connect the two DVOM leads across the input blades of the AC plug to read the input resistance of the system transformer

5. Look for a low reading of about 10 to 12 ohms to indicate continuity on the primary input circuit (primary side of the circuit)

6. Record your reading

7. Turn DVOM and microcomputer OFF

8. Have your instructor check your work

   (NOTE: A current reading can also be made with the DVOM, but this requires placing a lead in an open, active circuit, and that type of reading will be covered in a later job sheet.)

9. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TOOLS AND TEST EQUIPMENT
UNIT IV

JOB SHEET #2 — USE AN OSCILLOSCOPE TO CHECK A MICROCOMPUTER CLOCK SYSTEM

A. Tools and materials

1. Microcomputer as selected by instructor
2. Service manual or Computerfacts™ for selected microcomputer
3. Extender card for system bus (if available)
4. Dual-trace oscilloscope and operator's manual
5. Pencil and paper

B. Procedure for front-panel setup

1. Make sure scope is OFF
2. Set the vertical input range for both channels at approximately 5V because this is typically what a microprocessor clock voltage uses
3. Set the input selector for both channels on DC
4. Set the vertical mode of triggering so that both channels are triggered from channel #1

   (NOTE: This job sheet will use channels #1 and #2 throughout, so if your scope has A and B channels, #1 will be A, and #2 will be B.)

5. Set the horizontal time base to coincide with the period of one clock waveform, the time it takes to complete one waveform

   Example: If the clock is running at 1 MHz, it would take 1 microsecond to complete one clock period

6. Set the timebase controller in the ALTERNATE mode, if this is a chopped-type dual-trace timebase
7. Set the horizontal mode of triggering so that it triggers from channel #1
8. Set for internal triggering

   (NOTE: If you have a scope with automatic triggering, input levels and other triggering settings do not have to be made manually.)

9. Set the coupling selector to DC, if there is a selector

JOB SHEET #2

10. Turn the oscilloscope ON and let it start warming up

11. Have your instructor check your setup before continuing

C. Procedure for checking clock and timing signals

   1. Allow scope to fully warm up

   2. Set intensity and focus for a sharp, clear trace

   3. Set for automatic sweep

   4. Use the position knob to set the position of the channel #1 trace two divisions above center on the scope screen

   5. Use the same procedure to set the position of the channel #2 trace two divisions below center on the scope screen

      (NOTE: This should make the two traces equal distance from the center and from the top and bottom respectively.)

   6. Place the probe leads on the scope, if they are not already attached

   7. Place the channel #1 probe to ϕ1 of the clock system as identified in a schematic, and then connect the ground of the #1 probe to a ground in the circuit

   8. Place the channel #2 probe to ϕ2 of the clock system, and although the #2 ground does not need to be connected, make sure it doesn't touch any other part of the circuit

      (NOTE: With some leads, the ground can be detached.)

   9. Turn the microcomputer ON

   10. Check for two electrical waveforms on the scope screen, and make the fine adjustments required for the vertical and horizontal controls to produce waveforms that are equal in size to approximately one vertical division on the scope

   11. Adjust the position of the horizontal control so that the leading edge of the channel #1 waveform is the starting place of the ϕ1 clock

       (NOTE: In other words, have the ϕ1 clock coming through the zero reference on the left side of the scope.)

   12. Check to verify that the preceding adjustment caused ϕ2 to go in the opposite direction of ϕ1

       (NOTE: Remember that all microcomputer systems have both clock phases on the system bus, but there are other waveforms present on the bus also, so your instructor may have you check for other proper waveforms on the system bus.)

JOB SHEET #2

13. Record your findings and discuss your waveforms with your instructor

    (NOTE: One of the major objectives of this activity is not only to use the oscilloscope but to form a good mental picture of how the oscilloscope waveform actually compares with the waveform presented in a schematic.)

14. Change the horizontal sweep frequency setting to half what it was before

    Example: If it was 1 microsecond, change it to .5 microseconds

15. Check to see that the sweep adjustment doubled the size of the waveform on the scope screen

    a. If it does, move on to next item

    b. If it doesn't, check with your instructor

16. Record your findings

17. Change the volts per division on the vertical of channel #1 to the next lower division

18. Observe the result on the screen, and also observe what happens to the channel #2 trace

19. Change the volts per division on the vertical of channel #2 to coincide with the volts per division on channel #1

20. Make a sketch of the waveform at this point

21. Compare the waveform drawing from the schematic with the actual waveform as seen on the scope

22. Have your instructor check your work, and discuss your findings with your instructor

23. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TOOLS AND TEST EQUIPMENT
UNIT IV

JOB SHEET #3 — USE A FREQUENCY METER TO CHECK THE CLOCK FREQUENCY ON A MICROCOMPUTER SYSTEM BUS

A. Tools and equipment

1. Microcomputer as selected by instructor
2. Service manual or Computerfacts™ for microcomputer
3. Frequency meter
4. Extender card for system bus (if available)
5. Pencil and paper

B. Procedure

1. Make sure the frequency meter and the microcomputer under test are both turned OFF
2. Set the function knob to frequency counter if you are using a multiple service meter
3. Set the range setting so that it coincides or is perhaps a little higher than the clock frequency as determined from a schematic
4. Connect the negative black lead from the frequency meter to a ground in the circuit
5. Connect the positive red lead to the $\phi 1$ or $\phi 2$ clock

   (NOTE: The positive lead may be a probe that has to be placed and held on the test point, and remember that if you're using a system bus or extender card for this procedure that some system busses do not have a $\phi 1$ clock.)

6. Turn the frequency meter ON
7. Check for a reading of zero, and if it is different from zero, check the leads and test points
8. Turn the microcomputer ON
9. Read the digital display on the frequency meter and make a record of your reading expressed in MHz
10. Compare your reading with the frequency listed on the schematic

JOB SHEET #3

11. Have your instructor check your work

12. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TOOLS AND TEST EQUIPMENT
UNIT IV

NAME ____________________

TEST

1. Match the terms on the right with their correct definitions.

_____a.	A procedure for evaluating activity on the data bus of a microcomputer	1. SA
_____b.	A multirange test instrument popular in digital troubleshooting	2. DVOM
_____c.	A procedure for evaluating the unique signatures generated at single nodes within a microcomputer system and comparing those signatures with signatures made when the system was operating properly	3. Scope
_____d.	An abbreviated reference to an oscilloscope	4. DA
_____e.	The unique hexadecimal composition of any data node in a microcomputer circuit under test	5. Signature

2. Complete the following statements concerning standard hand tools for microcomputer repair by inserting the word(s) that best completes each statement.

   a. Assorted __________ and __________ screwdrivers for general disassembly and assembly

   b. Jewelers screwdriver set for __________ work on printers, disk drives, and microcomputers

   c. __________ set from 3/16" to 1/2" for general disassembly and assembly

   d. Hex __________ from 1/16" to 1/4" for general repair work

   e. Combination __________ __________ __________ __________ wrenches from 3/16" to 1/2" for general repair work

   f. __________ set containing both round and flat __________ for general work

   g. Standard __________ __________ pliers, 4" to 4 1/2" for holding

   h. __________ pliers for hard-to-get places

   i. Flat, __________ __________ pliers for parts holding

   j. Diagonal cutting pliers for work on __________ __________

TEST

k. Reversible ____________ ____________ pliers for removing and replacing ____________ ____________

l. Wire ____________ for cable makeup

m. Small hammer with ____________ head for tapping parts together

3. Complete the following list of special tools for handling IC's by inserting the word(s) that best completes each item in the list.

a. Chip extractor and ____________

b. ____________

c. ____________

d. IC test clips

1) 16-pin DIP test clip will work on both ____________-pin and 16-pin IC's

2) 28-pin DIP test clip will work on both ____________-pin and 28-pin IC's

3) 40-pin DIP test clip is used to test ____________

4. Solve the following problems concerning soldering equipment.

a. A fellow technician is desoldering on a PC board and using a sponge to pick up excess solder, but having problems with the effort

Solution ____

____

b. A fellow technician has made several complaints that something is wrong with the solder selected, and upon examination, it is apparent that the solder is not marked at all

Solution ____

____

5. Complete the following statements concerning lubrication tools and materials by inserting the word(s) that best completes each statement.

a. Plastic oiling bottles with ____________ ____________ ____________ are recommended for repair and maintenance service

b. High quality ____________ ____________ is used for some moving parts on both disk drives and printers

TEST

c. __________ __________ lubricants are specified for some printer and disk drive applications

d. __________ __________ lubricants are specified for some printer applications

6. Solve the following problems concerning adhesives and sealants.

   a. An adhesive used to resecure a printer part seems to be taking too long to dry

   Solution ____

   ____

   b. A fellow technician is reassembling a printer, and is using a lubricant but nothing else

   Solution ____

   ____

7. Complete the following list of inspection and cleaning tools by inserting the word(s) that best completes each item in the list.

   a. Small __________

   b. Inspection __________

   c. Small __________

   d. Small __________ __________

   e. __________ can

8. Solve the following problems concerning static control devices.

   a. A technician is on a service call but has forgotten to take along a static mat, but there is a can of anti-static spray in his tool kit. Should the technician go back to the shop and get a static mat?

   Solution ____

   ____

   b. A fellow student removes a chip from a PC board and sets it down on the workbench. What is wrong and how can it be corrected?

   Solution ____

   ____

TEST

9. Select true statements concerning tool kits by placing an "X" in the appropriate blanks.

_____a. Most service centers require technicians to buy and equip their own tool kits

_____b. Some tool kits may be especially equipped for a specific type of installation, and when checking out a tool kit for use in the field, make sure you have the right one

10. Complete the following statements concerning other specialty tools and equipment by inserting the word(s) that best completes each statement.

a. ____________ ____________ for controlling spikes and transients are a must in the repair center and in the field

b. Cables and ____________ are often required in repair activity

c. Shrink tubing and a ____________ ____________ to shrink it should both be available if needed

d. A set of ____________ knives is handy for making up cables

e. A supply of ____________ clips, wires, and nuts and bolts will come in handy, and the technician will learn from experience the incidental supplies that make the job easier

11. Select true statements concerning power supplies by placing an "X" in the appropriate blanks.

_____a. Additional power supplies should be available for troubleshooting microcomputer systems that require separate power supplies for driving add-ons and peripherals

_____b. A multi-range DC power supply will probably be needed often

_____c. A small 5V, high current power supply is also required for certain testing

TEST

12. Match electronic test instruments with their typical uses.

______a. Excellent instrument for troubleshooting power supplies and all kinds of power cables

______b. Only instrument that can provide a visual dual trace image for examining clock timing signals

______c. Gives a quick, accurate reading of clock frequency and saves hooking up an oscilloscope

______d. Logic type is used essentially to check voltage, logic pulsar can check line activity when system is off, and current tracer is effective for finding grounds and shorts on PC boards

1. Frequency meter
2. DVOM
3. Probes
4. Oscilloscope

13. Match special test instruments with their characteristics.

______a. An instrument that displays the electrical signatures unique to each data node so that a troubleshooter can compare working signatures with correct ones and isolate a faulty node

______b. A low-cost version of a signature analyzer that checks bus activity and does a good job isolating difficult problems related to software/hardware interaction

______c. A relatively expensive but effective instrument for checking speed, alignment, and general performance of a floppy disk drive

______d. A relatively expensive test instrument designed to replace and test the system microprocessor

______e. An inexpensive PC card that fits onto the system bus so that all signals on the bus are easily accessible for testing

1. Floppy disk analyzer
2. Extender card
3. Signature analyzer
4. Emulator
5. Data analyzer

TEST

14. Complete the following statements concerning DVOM operations by inserting the word(s) that best completes each statement.

    a. A DVOM is a multirange test instrument that will measure:

        1) ____________ or ____________ ____________

        2) ____________

        3) ____________

    b. A DVOM works with two control features:

        1) ____________ settings

        2) ____________ settings

    c. A DVOM has two test leads:

        1) Black or ____________

        2) Red or ____________

    d. A DVOM display is clear and ____________ ____________ ____________

    e. Most DVOM's have ____________ ____________ so that test leads do not have to be changed when troubleshooting both positive and negative readings

    f. The secret to successfully using a DVOM as an effective troubleshooting tool is to read the ____________ ____________ that comes with it and abide by all directions for general use

15. Complete the following statements concerning oscilloscope operations by inserting the word(s) that best completes each statement.

    a. An oscilloscope is a multifunction test instrument that converts electrical signals into ____________ that appear visually on a screen

    b. An oscilloscope has several front-panel control features, and understanding front-panel terminology is essential for effective operation:

        1) Two channels, usually 1 and 2 or ____________ and ____________

        2) ____________ and ____________ input controls

        3) Input selectors for ____________, ____________, and ____________

        4) ____________ functions with channel options

        5) Focus and ____________ controls

        6) Automatic ____________ selector

        7) Position control knob for ____________ ____________

TEST

c. An oscilloscope screen typically has __________ horizontal screen divisions with __________ above screen center and __________ below screen center

d. An oscilloscope usually has __________ identical leads, and each lead will have a hook or scissor-type clip for clipping onto a circuit

e. An oscilloscope lead will also have its __________ __________ __________ and this usually has an alligator clip attached to the end so it can be conveniently clipped to a __________

f. Oscilloscopes used for troubleshooting microcomputer systems must have a __________ __________ capability and have a capacity of at least 60 MHz

g. The secret to using an oscilloscope as an effective troubleshooting tool is to read the __________ __________ that comes with it, pay special attention to front-panel functions, and abide by all directions for general use

16. Select true statements concerning data analyzer operations by placing an "X" in the appropriate blanks.

______a. A data analyzer's primary function is to analyze the activity of the microcomputer address bus

______b. The data analyzer is connected to the address bus, to timing signals, and to ground

______c. Most data analyzers have a "recognizer probe" or module which allows a troubleshooter to recognize control conditions that are causing the problem

______d. The data analyzer recreates the fault condition that is causing the problem and permits examination of the data stream before and after a fault so the trouble can be analyzed

______e. Data analyzers are being used more and more in repair facilities because of their capability for quickly isolating the most troublesome microcomputer problems — hardware/software faults in combination

17. Select true statements concerning emulator operations by placing an "X" in the appropriate blanks.

______a. An emulator is designed to replace a microprocessor in a microcomputer system to provide a method for testing and evaluating all microprocessor activities within the system

______b. An emulator is designed to duplicate the functions of all microprocesors

______c. A micro system under test and running cannot tell that an emulator is in the circuit, so the emulator can change things under software control

TEST

_____d. With an emulator, a troubleshooter can reach into any point of a system to evaluate operations, or even store information for the troubleshooter to operate with

_____e. An emulator is an excellent troubleshooting tool, but to use it well, a troubleshooter needs a good background in the microcomputer system under test, and a good knowledge of the microprocessor and its machine language

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

18. Demonstrate the ability to:

    a. Use a DVOM to test a microcomputer system bus. (Job Sheet #1)

    b. Use an oscilloscope to check a microcomputer clock signal. (Job Sheet #2)

    c. Use a frequency meter to check the clock frequency on a microcomputer system bus. (Job Sheet #3)

TOOLS AND TEST EQUIPMENT
UNIT IV

ANSWERS TO TEST

1. a. 4
   b. 2
   c. 1
   d. 3
   e. 5

2. a. Flatblade, Phillips
   b. Interior
   c. Nutdriver
   d. Wrenches
   e. Open-end box-end
   f. File, files
   g. Slip joint
   h. Needlenose
   i. Duckbill-type
   j. PC boards
   k. Snap-ring, snap-rings
   l. Strippers
   m. Lucite

3. a. Inserter
   b. Tweezers
   c. Hemostat
   d. 1) 14
      2) 24
      3) Microprocessors

4. a. Use a desoldering wick
   b. Use properly labeled resin-cored solder

5. a. Leak-proof spouts
   b. Machine oil
   c. Teflon-based
   d. Graphite-based

6. a. Remove it and apply a fast-drying adhesive
   b. Certain parts require an adhesive too because they are subject to a great deal of vibration

7. a. Flashlight
   b. Mirror
   c. Brushes
   d. Vacuum cleaner
   e. Spray

ANSWERS TO TEST

8. a. No. Use the anti-static spray
   b. The chip is subject to static damage and should be placed on a piece of static foam

9. b

10. a. Surge protectors
    b. Connectors
    c. Heating gun
    d. X-Acto
    e. Miscellaneous

11. a,b,c

12. a. 2
    b. 4
    c. 1
    d. 3

13. a. 3
    b. 5
    c. 1
    d. 4
    e. 2

14. a. 1) AC, DC voltage
       2) Current
       3) Resistance
    b. 1) Function
       2) Range
    c. 1) Negative
       2) Positive
    d. Easy to read
    e. Automatic polarity
    f. Operator's manual

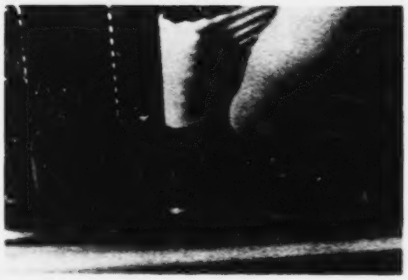
15. a. Waveforms
    b. 1) A, B
       2) Vertical, horizontal
       3) AC, DC, ground
       4) Triggering
       5) Intensity
       6) Sweep
       7) Screen placement
    c. Eight, four, four
    d. Two
    e. Own ground lead, ground
    f. Dual-trace
    g. Operator's manual

ANSWERS TO TEST

16. c,d,e

17. a,c,d,e

18. Performance competencies evaluated according to procedures specified in the job sheets



BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the structure of system busses and identify specific pin functions on selected busses. The student should also be able to discuss the RS-232-C and centronics communications standards and assemble an RS-232-C cable. These competencies will be evidenced by correctly completing the procedures outlined in the job sheet and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to busses, protocols, and handshakes with their correct definitions.
2. Match system busses with their characteristics.
3. Differentiate between types of system busses.
4. Differentiate between types of application cards for system busses.
5. List four signal groups in a system bus.
6. Complete statements concerning using the system bus as a troubleshooting tool.
7. Complete statements concerning typical system busses.
8. Complete statements concerning general information about the IBM PC® bus.
9. Complete statements concerning power supply pins on the IBM PC® bus.
10. Complete statements concerning timing signals on the IBM PC® bus.

OBJECTIVE SHEET

11. Complete statements concerning control signals on the IBM PC® bus.
12. Complete statements concerning DMA control signals on the IBM PC® bus.
13. Complete statements concerning general information about the Apple II® bus.
14. Complete statements concerning timing signals on the Apple II® bus.
15. Complete statements concerning power supply pins on the Apple II® bus.
16. Complete statements concerning control and line signals on the Apple II® bus.
17. Solve problems concerning DMA and interrupt signals on the Apple II® bus.
18. Solve a problem concerning color signals on the Apple II® bus.
19. Complete statements concerning general information about the TRS-80® bus.
20. Locate data and address line signals on the TRS-80® bus.
21. Complete statements concerning control signals on the TRS-80® bus.
22. Solve a problem concerning electrical signals on the TRS-80® bus.
23. Match other types of busses with their characteristics.
24. Complete statements concerning the RS-232-C standard.
25. Complete statements concerning electrical parameters for the RS-232 standard.
26. Arrange in order typical steps in a RS-232 communication.
27. Complete statements concerning parity and how it works.
28. Complete statements concerning mechanical specifications for the RS-232.
29. Solve problems concerning other EIA pin specifications for the RS-232.
30. Select true statements concerning RS-232 relationships with DCE and DTE devices.
31. Complete statements concerning the centronics standard.
32. Solve a problem concerning pin arrangements for the centronics standard.
33. Arrange in order typical steps in a centronics communication.
34. Complete statements concerning types of cables used with RS-232 and centronics standards.

OBJECTIVE SHEET

35. Complete statements concerning cable assembly techniques.

36. Complete statements concerning special tools required for cable assembly.

37. Complete a list of special materials for cable assembly.

38. Arrange in order the steps in documenting cable assemblies.

39. Demonstrate the ability to assemble an RS-232 cable connector. (Job Sheet #1)

BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

SUGGESTED ACTIVITIES

A. Provide students with objective sheet.

B. Provide students with information and job sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheet.

F. Discuss and demonstrate the procedures outlined in the job sheets.

G. Invite a systems representative from a local or area company active in networking on any level, and have the representative talk to the class about the types of protocols used for local area networks and national networks, and why protocols are so important to the proper handling and transmission of all kinds of data.

H. Invite a representative from a local or area industry that used microprocessor-based controls to talk to the class about industrial busses used for manufacturing and scientific purposes.

I. For valuable information about interfacing hardware, tools, and materials, write for the black box catalog to: Black Box Corporation, P.O. Box 12800, Pittsburg, PA 15241, or call (412) 746-5530. The catalog is free and simply ordering it will get you on a mailing list that will bring you other valuable free materials such as the Black Box newsletter.

J. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Transparency masters

   1. TM 1 — IBM PC® Bus

   3. TM 2 — Apple II® Bus

   4. TM 3 — TRS-80® I/O Bus

D. Job #1 — Assemble an RS-232 Cable Connector

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Poe, Elmer C., and James C. Goodwin. *The S-100 and Other Micro Busses.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1979.

B. Johnson, Chris. *The Microcomputer Builder's Bible.* Blue Ridge Summit, PA 17214: Tab Books Inc., 1982.

C. Kershaw, John D. *Digital Electronics Logic and Systems, Second Edition.* Belmont, CA 94002: Breton Publishers, a Division of Wadsworth, Inc., 1983.

D. Camp, R.C., and T.A. Smay and C.J. Triska. *Microprocessor Systems Engineering.* Portland, OR 97210: Dilithium Press, 1981.

E. *Black Box Catalog of Data Communications and Computer Devices.* Pittsburg, PA 15241: Black Box Corporation, July 1985.

BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

INFORMATION SHEET

I. **Terms and definitions**

A. Defacto — Something that attains status through popular usage, not from formal recognition

B. Handshake — A communications exchange accomplished with hardware

C. Interface — The point where two components connect within a system and/or the device used to make the connection

D. Parameters — Specifications by which the likeness of things can be compared

E. Parity — Keeping one thing equal to another, a balancing

F. Protocol — A communications exchange accomplished with software

II. **System busses and their characteristics**

A. The concept — System busses create a uniform method for handling signals required by the system, make a product easy to work on, and provide upward compatibility for adding on devices with advanced circuitry

B. The function — System busses handle addressing signals, data signals, and control signals for the microprocessor in its relations with other system components and for the system bus itself in its relation with application cards added to the bus

C. The shape — The system bus usually takes the form of a printed circuit board with edgeboard connectors designed to house the cards within the system and to transport signals from the bus to the cards

III. **System busses and their uses**

A. Microcomputer — A system bus designed with addressing signals, data signals, and control signals to manage operations of a microcomputer system

B. Industrial — A system bus designed for the specific purpose of interfacing scientific or other specialized instruments with a control system

INFORMATION SHEET

IV. **Types of application cards for system busses**

A. Master card — Any card that has on board a microprocessor or any other capability for controlling the bus

B. Slave card — Any card that does not have bus control capability

(NOTE: A slave card may interface and communicate with the system bus, but some other card must control it.)

V. **Signal groups in a system bus**

A. Power supply voltages

B. Data signals

C. Address signals

D. Control signals

1. Control signals for the microprocessor

2. Control signals for the system bus itself

(NOTE: There are certain interchanges from card to card that do not require a need for the microprocessor, and these interchanges are handled by the system bus control signals.)

VI. **Using the system bus as a troubleshooting tool**

A. The system bus provides easy access for a troubleshooter to check, test, and otherwise troubleshoot a system

B. The signals from the system bus consist of all the major electrical signals available to the system and can be selectively used to evaluate specific parts of a system

C. An easy technique for gaining access to the system bus is to use a "bus extender card" which can be purchased commercially or easily put together from materials available at almost all electronic shops

(NOTE: The Vector company makes extender cards for all commonly used system busses.)

VII. **Typical system busses**

A. Apple II® bus — Apple refers to their bus as a "peripheral connector"

B. TRS-80® bus — The only external pin connections available for general use are at the I/O port connector

INFORMATION SHEET

C. IBM PC® bus — a valuable bus for troubleshooters to learn because of the popularity of the IBM product line and the use of a compatible bus by many other manufacturers seeking to produce IBM-compatible products

VIII. **General information about the IBM PC® bus** (Transparency 1)

A. A bus with 62 pin connectors

B. Is labeled with an A and B side

C. All A's and B's are opposite each other from 1 to 31, that is, A1 is opposite B1 and on to A31 which is opposite B31 (giving 62 pins)

D. Address lines A0 through A19 have a backward correlation to pins #A31 through #A12, in other words, address line zero (A0) is at pin #A31 and address line nineteen (A19) is at pin #A12

E. Data lines D0 through D7 are in order starting at pin #A2 and going through pin #A9 respectively

F. This is a popular bus and a good one for troubleshooters to learn because it is a "defacto" standard bus which promises to be common in the microcomputer industry

IX. **Power supply pins on the IBM PC® bus** (Transparency 1)

A. +5V is found on two pins, #B3 and #B29

B. -5V is found on only pin #B5

C. +12V is found on only pin #B9

D. -12V is found on only pin #B7

E. Gnd is found on three pins, #B1, #B31, and #B10

X. **Timing signals on the IBM PC® bus** (Transparency 1)

A. Pin #B30 labeled OSC is the oscillator signal coming into the system at 14.31818 MHz

(NOTE: The 14.31818 MHz frequency is used so it can be readily divided down to get the 3.58 MHz color burst signal for RGB, and the OSC has a period of approximately 70 nanoseconds and a 50% duty cycle.)

B. Pin #B20 labeled CLK is the 4.77 MHz clock signal

(NOTE: The 4.77 MHz is obtained by dividing the OSC signal by three, and this signal becomes a one-third/two-third duty cycle where the high time is 70 nanoseconds and the low time is 140 nanoseconds to make a total time period of 210 nanoseconds.)

INFORMATION SHEET

XI. **Control signals on the IBM PC® bus** (Transparency 1)

A. Pin #B2 labeled RESET DRV is the reset driver signal that is held high during power on reset sequence

B. Pin #B28 labeled ALE is the address latch enable signal which goes active just prior to the address being valid and goes inactive when the address bus is valid

(NOTE: The ALE pin is used to latch address information out of the 8088 microprocessor.)

C. Pin #A1 labeled $\overline{\text{IO CH CK}}$ is the input/output channel check that checks all interface cards added to the bus and reports any error conditions back to the 8088 microprocessor

(NOTE: The error report triggers an $\overline{\text{NMI}}$ in the microprocessor.)

D. Pin #A10 labeled I/O CH RDY is the input/output channel signal that extends the bus cycle timing as much as 21 nanoseconds (10 clocks) to accomodate slow I/O devices

E. Pin #B14 labeled IOR is the standard output signal from the 8288 bus controller card

F. Pin #B13 labeled IOW is the I/O signal from the 8288 bus controller

(NOTE: Pins #B13 and #B14 are the controllers for I/O in and out.)

G. Pin #B11 labeled MEMW is the memory write signal that comes from the 8288 bus controller (and in turn out of the microprocessor) and causes information on the system data bus to be written into memory

H. Pin #B12 labeled MEMR is the memory read signal that signals information should be transferred from memory to the system data bus

XII. **DMA control signals on the IBM PC® bus** (Transparency 1)

A. Pin #B18 labeled DRQ1, pin #B26 labeled DRQ2, and pin #B16 labeled DRQ3 are the three DMA request lines that permit a device to transfer information between memory and that device without intervention of the microprocessor

B. Pin #B19 labeled DAK0, pin #B17 labeled DAK1, pin #B26 labeled DAK2, and pin #B15 labeled DAK3 are all signals issued by the 8237 DMA controller chip to indicate that a DRQ has been honored

C. Pin #A11 labeled AEN is an address enable signal put out by the DMA controller to indicate to other parts of the system that a DMA transfer is in process and to stay off the bus because it's busy

D. Pin #B27 labeled T/C is the terminal count signal issued by the DMA controller to indicate that one of the DMA channels has reached its programmed limit of cycles

INFORMATION SHEET

XIII. **General information about the Apple II® bus** (Transparency 2)

A. Apple refers to its bus as a "peripheral connector bus"

B. It is a 50-pin bus designed to accept PC cards with edge connectors

(NOTE: Two pins in the bus are not used, so there are 48 active pins on the bus.)

C. Has 16 address lines and 8 data lines and has some control signals connected through buffering components directly with the microprocessor

D. As the name peripheral connector implies, the bus treats each pin connection as a peripheral location

XIV. **Timing signals on the Apple II® bus** (Transparency 2)

A. Pin #36 is the 7 MHz clock that comes from the oscillator and is divided down to give the 3.58 MHz color signal

B. Pin #37 is called the Q3 signal which is a 2 MHz clock signal used for various activities around the system

C. Pin #38 is the $\phi1$ clock or the microprocessor clock that does the addressing

D. Pin #40 is the $\phi0$ clock which is a signal from the oscillator that serves as an input frequency for the microprocessor

XV. **Power supply pins on the Apple II® bus** (Transparency 2)

A. Pin #25 is +5V

B. Pin #26 is gnd

C. Pin #33 is -12V

D. Pin #34 is -5V

E. Pin #50 is +12V

XVI. **Control and line signals on the Apple II® bus** (Transparency 2)

A. Pin #1 labeled I/O SELECT is the signal that the microprocessor uses to select a particular peripheral location

(NOTE: Remember that this bus is called a peripheral connector bus, so the I/O SELECT normally stays high but goes low when the microprocessor selects a particular slot to activate peripheral operation.)

INFORMATION SHEET

B. Pins #2 through #17 are the locations of the 16 address lines which are numbered in order with A0 being at pin #2 and A15 being at pin #17

C. Pin #18 labeled R/W is the buffered read/write signal which goes high to read and low to write and is timed by the system clock so that it becomes valid when the address bus does

D. Pin #20 labeled $\overline{\text{I/O STROBE}}$ selects addresses between hex C800 and hex CFFF, and these are areas specified as I/O control areas

E. Pin #21 labeled $\overline{\text{RDY}}$ is the signal that goes to the ready line on the microprocessor, and will halt the microprocessor when it is low during the $\phi 1$ clock

F. Pins #42 through #49 are the locations of the 8 data lines which are numbered in reverse with D7 being at pin #42 and D0 being at pin #49

G. Pin #41 labeled $\overline{\text{DEVICE SELECT}}$ is a low going signal that indicates that the address bus is holding the address that contains the slot number plus the hex 8 within its address span

(NOTE: These predetermined addresses are held in the second nibble of the hex number identifying the address, or in other words, the slots are numbered 0 through 7, so adding 8 to these numbers gives 8, 9, ABCDEF which is 8 through 15 in hex.)

XVII. **DMA and interrupt signals on the Apple II® bus** (Transparency 2)

A. Pin #22 labeled $\overline{\text{DMA}}$ is the signal that disables the address bus on the 6502 microprocessor when it goes low

B. Pin #24 labeled DMA OUT functions along with pin #27, DMA IN, to set priorities on direct memory lines which serves to let the line with the next highest priority know when it can get on the bus

C. Pin #27 labeled DMA IN takes input from higher priority devices and functions with pin #24, DMA OUT as outlined

D. Pin #23 labeled INT OUT functions with pin #28, INT IN to set interrupt priorities from high to low and to notify the next highest priority when it can go on line

E. Pin #28 labeled INT IN daisy chains the interrupt inputs from the higher priority devices and functions with pin #23 as outlined above

F. Pin #29 labeled $\overline{\text{NMI}}$ is the nonmaskable interrupt signal that goes straight to the $\overline{\text{NMI}}$ pin on the 6502 microprocessor to interrupt the 6502 and send it to hex location 03FB

INFORMATION SHEET

G. Pin #30 labeled $\overline{\text{IRQ}}$ is the interrupt request signal and will interrupt the 6502 microprocessor when it goes low and otherwise function as does the $\overline{\text{NMI}}$

H. Pin #31 labeled $\overline{\text{RES}}$ is the reset signal and will interrupt the 6502 microprocesor when it goes low and cause the 6502 to return to the monitor

I. Pin #32 labeled $\overline{\text{INH}}$ is another low going signal that disables ROM on the Apple board so it can be overlaid

XVIII. **Color signals on the Apple II® bus** (Transparency 2)

A. Pin #19 labeled SYNC gives the video timing synchronization and is found only on peripheral edge card connector #7

B. Pin #35 labeled COLOR REF sits next to the video generator and is connected to the 3.58 MHz color signal, and it too is found only on peripheral edge card connector #7

(NOTE: When troubleshooting video problems with an Apple II or II Plus, it's good to remember pins #19 and #35.)

XIX. **General information about the TRS-80® bus** (Transparency 3)

A. Unlike other system busses, this bus is different because it is essentially an I/O port with almost no direct relationship to the microprocessor

B. The I/O port does have buffered input to the data bus and buffered output from address lines A0 through A7

C. The bus contains an 8-bit parallel printer port with a centronics handshake

D. Because of its structure, the TRS-80 bus is not much use as a troubleshooting tool unless a malfunction occurs when an I/O device is attached

XX. **Data and address line signals on the TRS-80® bus** (Transparency 3)

A. D0 through D7 are found in order on pins #1, #3, #5, #7, #9, #11, #13, and #15

B. Address lines A0 through A7 are found in order on pins #17, #19, #21, #23, #25, #27, #29, and #31

XXI. **Control signals on the TRS-80® bus** (Transparency 3)

A. Pin #33 is an input control pin

B. Pin #35 is an output control pin

C. Pin #39 labeled IOBUSINT is an interrupt

INFORMATION SHEET

D. Pin #41 labeled IOBUSWAIT is an incoming signal that tells the system when to wait

E. Pin #43 labeled EXTIOSEL connects the microprocessor external I/O device select pin and it will remain high until pulled low by an external device that enables the 8 data lines

(NOTE: When the external device is pulled low, it will allow the external I/O device to place 8 bits of information on the data bus going back into the system.)

F. Pin #49 is an I/O request pin that goes back to the microprocessor

G. All even numbered pins are ground pins and pin #45 is not used

XXII. **Electrical signals on the TRS-80® bus** (Transparency 3)

A. Pins #8, #19, and #37 serve as common grounds for power supplies and signals

B. Pin #39 serves as a ground on certain models and as a +5V power supply on other models

C. There are no clock functions integrated into the TRS-80 bus

XXIII. **Other types of busses and their characteristics**

A. VME — An industrial bus designed by Motorola for use with Motorola microprocessor parts and specifically the Motorola MCS68000

(NOTE: There are a number of small industrial computer products that use the VME bus, but the bus is not used in any popular brands of microcomputers.)

B. IEEE 488 — An instrumentation bus designed by Hewlett-Packard to make computer products compatible with electronic and scientific instruments

(NOTE: This bus is used in both mini and microcomputers, and some manufacturers are building the IEEE 488 into their microcomputer so the systems will be capable of interfacing directly with scientific instruments, an excellent example of designed upward compatibility.)

C. TI — The Texas Instruments bus is the only true 16-bit microcomputer bus, but the bus is no longer in use since TI withdrew from the microcomputer market

D. Zilog — This bus was designed specifically for use with the Z-80 microprocessor, is now used only on some single board products and is still popular with hobbyist, but not used in numbers in the microcomputer market

INFORMATION SHEET

E. S-100 — This bus is still popular with hobbyists, but is not a bus that technicians will often confront in troubleshooting.)

F. Intel SBC Multibus® — A bus not widely used in microcomputers, but a valuable bus for troubleshooters to learn because it is an excellent bus design and will help a troubleshooter better understand other bus structure

XXIV. **The RS-232-C standard**

A. The RS-232-C is a communications standard written by the Electronics Industry Association and recommended as a guide for communicating digital information

(NOTE: Technically speaking, the RS means recommended standard, the 232 is an arbitary number assigned by the EIA, and the C indicates the version number.)

B. The RS-232 is specifically a standard for communicating digital information in serial form

(NOTE: In most references the "C" is dropped and only the RS-232 is used.)

C. The RS-232 standard has two very important elements:

1. The electrical parameters involved, including the voltage levels that are acceptable, and specific pin connections that must agree with the written standard

2. The communications protocol involved, including handshaking and the high and low bit signals used to indicate the beginning and end of the ASCII data word being transmitted

(NOTE: Some terminology refers to a high signal as a "mark" and a low signal as a "space," so a reference to "mark and space" in any literature will be a reference to the high and low bit signals in the standard.)

XXV. **Electrical parameters for the RS-232 standard**

A. RS-232 voltages are not compatible with TTL logic

B. To comply with the RS-232 standard, voltages must range between -3V and -15V and +3V and +15V

C. RS-232 logic 1 can be any voltage between -3V and -15V

D. RS-232 logic 0 can be any voltage between +3V and +15V

E. The most common voltages used with RS-232 are +5V and -5V and +12V and -12V because these are the voltages commonly available from a system power supply

INFORMATION SHEET

XXVI. **Typical steps in a RS-232 communication**

A. In order to begin a serial communication in the standard, the logic level must be high

B. At the start of a character transmission, the logic level must go low for one time period

(NOTE: A time period is determined by the speed of transmission which is rated in BAUD, and for the sake of this example a 1200 BAUD rate will be used so that signal bit time will be 833 microseconds.)

C. The signal will stay low for one bit time and this is referred to as the start bit

(NOTE: Remember that the signal has to be at high logic before it goes low for the start bit.)

D. Following the start bit, there will be seven data bits at the same time frame and all seven bits of information will be in ASCII code

(NOTE: At a 1200 BAUD rate, each of the seven bits will be 833 microseconds long within the character.)

E. The next bit transmitted will be the 8th bit or the parity bit which serves as an error checking bit, and may be high or low in accordance with the parity required

(NOTE: Parity and the 8th bit will be discussed in a later objective.)

F. Following the parity bit will be the stop bit which will be at logic 1 or high

(NOTE: In low BAUD rates such as 110 BAUD, two stop bits are used instead of one, but whatever the case, the stop bit or bits terminate the character transmission.)

G. A transmission is complete when it contains one start bit, seven data bits, and one or two stop bits

(NOTE: It takes this specific arrangement to make up a single character.)

H. After the stop bit(s) the machine can idle at logic high until it goes low for one bit time which will start the transmission cycle over again

XXVII. **Parity and how it works**

A. Whether there is parity or no parity must be set up as part of the communications protocol, and if there is parity, it must either be:

1. Even parity
2. Odd parity

INFORMATION SHEET

B. Since even parity means that a word must contain an even number of bits, any word that contains an odd number of bits must be modified:

1. A parity bit must be added to even the numbers and make the signal go high before transmission
2. The even number of bits is then checked for at the other end of the communication by the parity checking bit

C. Since odd parity means that a word must contain an odd number of bits, any word that contains an even number of bits must be modified:

1. A parity bit must be added to make the numbers odd and make the signal go low before transmission
2. The odd number of bits is then checked for at the other end of the transmission by the parity checking bit

D. Parity can be generated by readily available hardware and software mechanisms

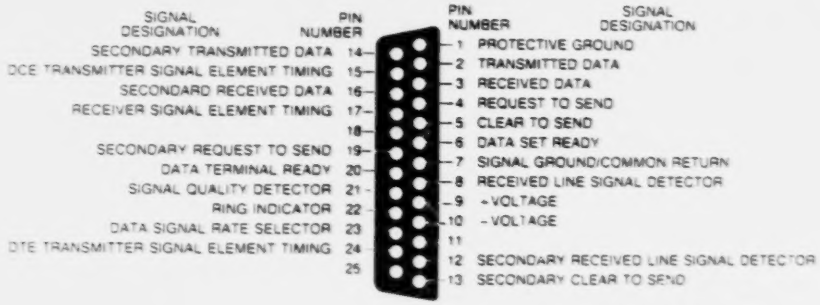
XXVIII. **Mechanical specifications for the RS-232** (Figure 1)

A. The mechanical configuration complete with electrical requirements for specific pin locations are written into the standard

B. The standard requires a "D" type connector of 25 pins arranged in two rows with 13 pins in one row and 12 pins in one row

FIGURE 1

RS-232 Interface


SIGNAL DESIGNATION
PIN NUMBER
SECONDARY TRANSMITTED DATA 14
DCE TRANSMITTER SIGNAL ELEMENT TIMING 15
SECONDARD RECEIVED DATA 16
RECEIVER SIGNAL ELEMENT TIMING 17
18
SECONDARY REQUEST TO SEND 19
DATA TERMINAL READY 20
SIGNAL QUALITY DETECTOR 21
RING INDICATOR 22
DATA SIGNAL RATE SELECTOR 23
DTE TRANSMITTER SIGNAL ELEMENT TIMING 24
25
PIN NUMBER
SIGNAL DESIGNATION
1 PROTECTIVE GROUND
2 TRANSMITTED DATA
3 RECEIVED DATA
4 REQUEST TO SEND
5 CLEAR TO SEND
6 DATA SET READY
7 SIGNAL GROUND/COMMON RETURN
8 RECEIVED LINE SIGNAL DETECTOR
9 +VOLTAGE
10 -VOLTAGE
11
12 SECONDARY RECEIVED LINE SIGNAL DETECTOR
13 SECONDARY CLEAR TO SEND

© Black Box Corporation; reprinted with permission

INFORMATION SHEET

C. Pin numbers are impressed into the protective casing around the D connector to avoid errors in identifying pin numbers

D. Among the EIA pins specifications, the following are very important primary pins:

1. Pin #2 — Transmitted data
2. Pin #3 — Received data
3. Pin #4 — Request to send
4. Pin #5 — Clear to send
5. Pin #6 — Data set ready
6. Pin #7 — Common ground for signal
7. Pin #20 — Data terminal ready

(NOTE: Pin #20 correlates with pin #6.)

E. Pins #2 and #3 control the direction of data on the bus

F. Pins #4, #5, and #6 establish protocol and also accomplish a handshake arrangement for sending information back and forth

(NOTE: Some technicians would not call this arrangement a handshake, but it accomplishes the same objective.)

G. It is a common practice with serial printers to use only pins #2, #3, and #7

H. When protocol requires a handshaking arrangement, pins #4, #5, #6, and #20 are used

I. A full bidirectional communications link will require not only primary pins, but also the following secondary pins:

1. Pin #12 — Secondary receive line signal detector
2. Pin #13 — Secondary clear to send
3. Pin #14 — Secondary transmitted data
4. Pin #16 — Secondary received data
5. Pin #19 — Secondary request to send

(NOTE: Notice how the secondary pins correspond to similar primary pin functions.)

INFORMATION SHEET

XXIX. **Other EIA pin specifications for the RS-232** (Figure 1)

A. Pin #1 is the protective ground and should not be confused with the signal ground at pin #7

B. Pin #8 is a receive line protector

C. Pins #9 and #10 are reserved for data testing

D. Pin #15 is the transmission signal element timing for a DCE source, and pin #17 is the receiver signal element timing for a DCE source

E. Pin #21 is the signal quality detector

F. Pin #22 is a ring indicator which will make a bell ring

G. Pin #23 is the data signal rate selector for both DCE and DTE sources

H. Pin #24 is the transmission signal element timing for DTE source only

I. Unused pins include #11, #18, and #25

XXX. **RS-232 relationships with DCE and DTE devices** (Figure 1)

A. Data communications equipment devices, like modems, have the capacity for bidirectional communications

B. Data terminal equipment devices, like printers and video displays, are usually unidirectional and receive but do not send information

C. Although DTE devices are unidirectional, it is not uncommon to find a handshake on a DTE device, and this would include:

   1. Pin #4 — Request to send
   2. Pin #5 — Clear to send
   3. Pin #6 — Data set ready
   4. Pin #20 — Data terminal ready
   5. Pin #1 — Protective ground, optional, but present on a good DTE arrangement

XXXI. **The centronics standard** (Figure 2)

A. The centronics standard is actually a “defacto” standard used for communicating digital information usually in parallel form

B. The centronics connector is a 36-pin device used most frequently for connecting parallel printers to microcomputers and may be made with a round cable which is usually soldered or a ribbon cable of the solderless clamp-on type

C. A centronics cable usually leaves a microcomputer through a DB 25 connector on the microcomputer's parallel printer port

INFORMATION SHEET

D. A centronics cable usually enters the printer through a 36-pin centronics male connector which inserts into the 36-pin female centronics receptacle built into the printer

XXXII. **Typical pin arrangements for the centronics connector** (Figure 2)

A. Pin #1 is data strobe and pin #19 the return

B. Pins #2 through #9 are the data bit pins with pins #20 through #27 the returns

C. Pin #10 is ACK (acknowledge) and pin #28 is the return

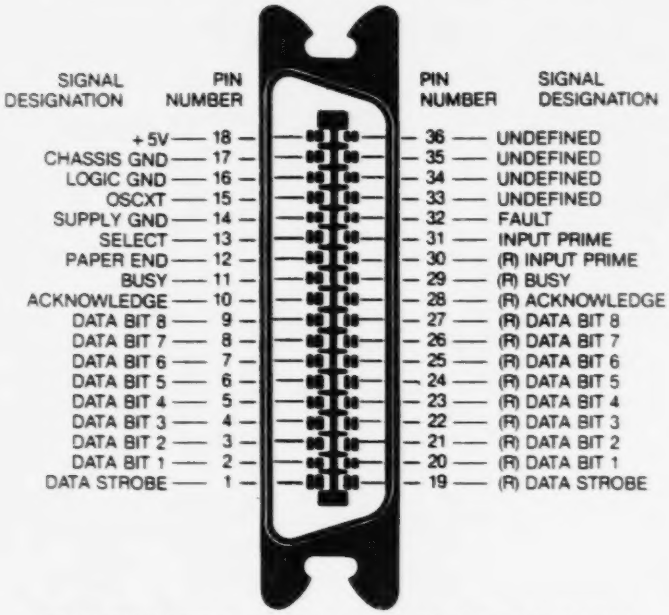
D. Pin #11 is BUSY and pin #29 is the return

E. Pin #16 is the logic ground and pin #17 is the chassis ground

F. Other pins vary with application, but are normally used for auxiliary printer controls and error handling, and other pins are not used

FIGURE 2

Parallel Interface (Centronics type)


SIGNAL DESIGNATION
PIN NUMBER
PIN NUMBER
SIGNAL DESIGNATION
+5V — 18
CHASSIS GND — 17
LOGIC GND — 16
OSCXT — 15
SUPPLY GND — 14
SELECT — 13
PAPER END — 12
BUSY — 11
ACKNOWLEDGE — 10
DATA BIT 8 — 9
DATA BIT 7 — 8
DATA BIT 6 — 7
DATA BIT 5 — 6
DATA BIT 4 — 5
DATA BIT 3 — 4
DATA BIT 2 — 3
DATA BIT 1 — 2
DATA STROBE — 1
36 — UNDEFINED
35 — UNDEFINED
34 — UNDEFINED
33 — UNDEFINED
32 — FAULT
31 — INPUT PRIME
30 — (R) INPUT PRIME
29 — (R) BUSY
28 — (R) ACKNOWLEDGE
27 — (R) DATA BIT 8
26 — (R) DATA BIT 7
25 — (R) DATA BIT 6
24 — (R) DATA BIT 5
23 — (R) DATA BIT 4
22 — (R) DATA BIT 3
21 — (R) DATA BIT 2
20 — (R) DATA BIT 1
19 — (R) DATA STROBE

(R) INDICATES SIGNAL GROUND RETURN

© Black Box Corporation; reprinted with permission

INFORMATION SHEET

XXXIII. **Typical steps in a centronics communication**

A. Upon a command from the microcomputer, the strobe signal goes low and data is strobed onto the eight parallel data lines simultaneously

B. The strobe alerts the printer that data is on the line and the printer accepts the information

(NOTE: Data is on the line the same time as the strobe and data remains on the line even after the strobe signal goes back to high again.)

C. At the time the printer receives the data, it will then send a low going acknowledge signal back to the microcomputer

D. As soon as the acknowledge signal is received by the microcomputer, the microcomputer knows it can strobe new data to the printer and the cycle will be repeated

(NOTE: As with the RS-232, a centronics transmission uses ASCII code and the 7 bits of ASCII data transmitted may or may not include parity.)

XXXIV. **Types of cables used with RS-232 and centronics standards**

A. Round cables may be used and usually have soldered connections

B. Flat ribbon cables may be used and these are usually solderless with clamp-on connections

C. All peripheral cable connections are expensive, and for that reason building both RS-232 and centronics cables is sometimes part of troubleshooting and repair work

XXXV. **Cable assembly techniques**

A. Soldering cables is a traditional technique, but cable quality depends on the soldering skill of the technician, and soldered cables are difficult to service or change in the field

B. The pin insertion technique is much easier for the beginner, and results are more consistent than with soldered cables, and the cables are easier to service or change in the field

XXXVI. **Special tools required for cable assembly** (Figure 3)

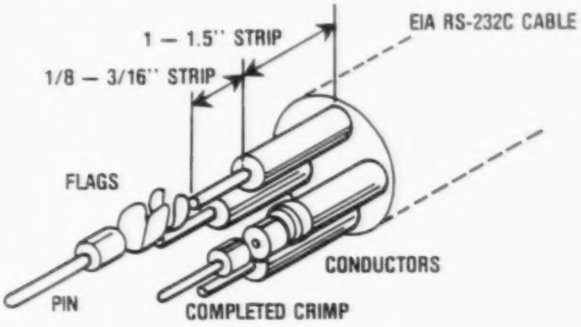
A. Wire cutter/stripper for properly removing insulation from cables and conductors

B. Pin insertion/extraction tool to insert or remove crimp-type pins in D series connector shells

INFORMATION SHEET

C. Crimping tool to crimp the flags or holding flanges on pins

FIGURE 3


1 — 1.5'' STRIP
1/8 — 3/16'' STRIP
EIA RS-232C CABLE
FLAGS
CONDUCTORS
PIN
COMPLETED CRIMP

© Black Box Corporation; reprinted with permission

XXXVII. **Special materials for cable assembly** (Figure 4)

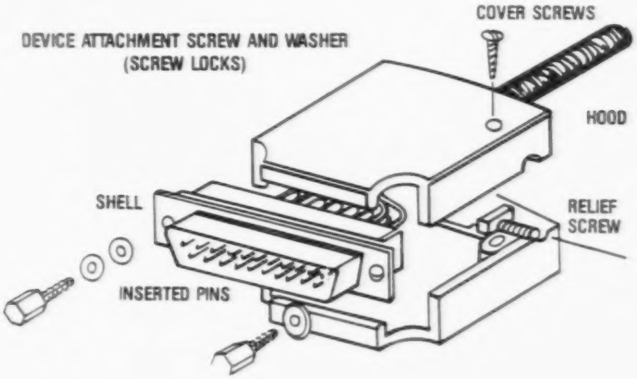
A. Male or female pins/sockets

B. Two-part hood or shell

C. Screw locks or attachment screws and washers

D. Strain relief screw or device

FIGURE 4


COVER SCREWS
DEVICE ATTACHMENT SCREW AND WASHER
(SCREW LOCKS)
HOOD
SHELL
RELIEF SCREW
INSERTED PINS

© Black Box Corporation; reprinted with permission

INFORMATION SHEET

XXXVIII. **Steps in documenting cable assemblies** (Figure 5)

A. Sketch or make a formal drawing of the pin connections in the assembly

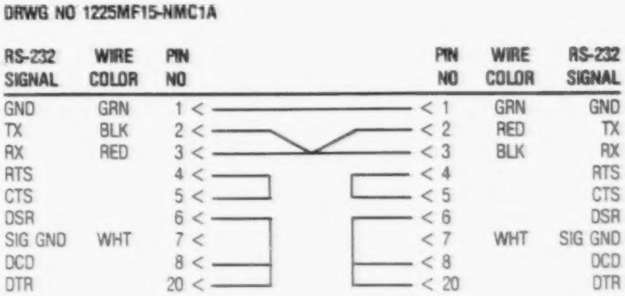
(NOTE: It saves money to use only the connections required, but in many cases, it always pays to allow for any future signal expansion.)

B. Identify the basic cable type, other important elements in the assembly, then give the drawing a reference number

C. When the assembly is completed, label it with the reference number of the drawing

D. File the original drawing or sketch along with its reference ID so it can be found if the cable needs servicing or changing

FIGURE 5

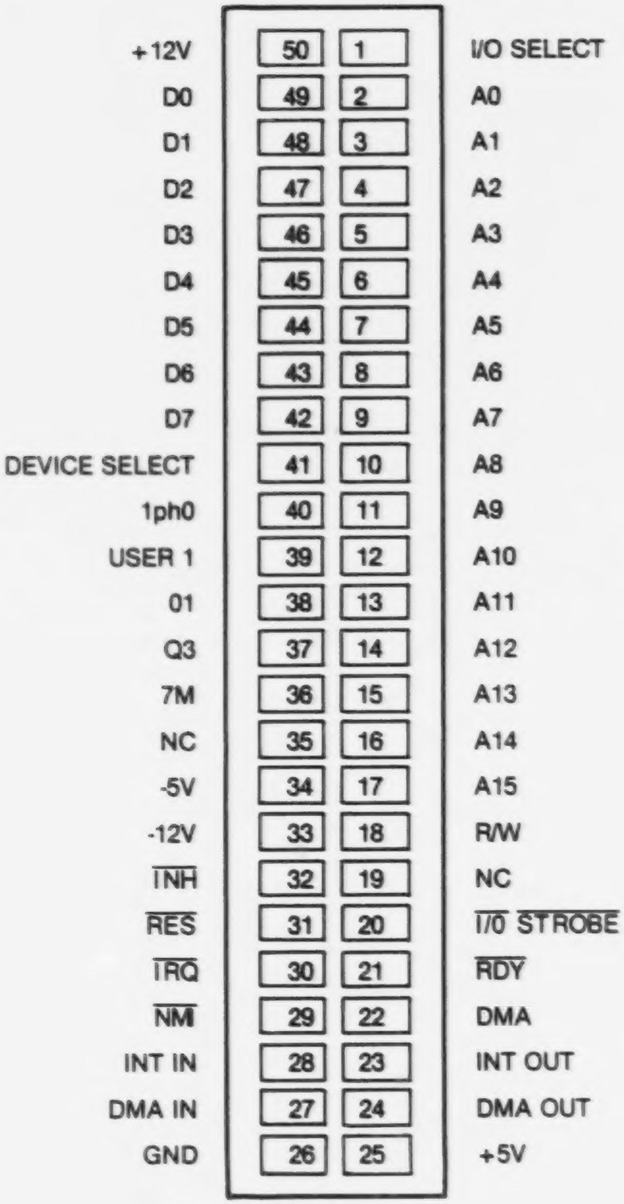

DRWG NO 1225MF15-NMC1A
RS-232 SIGNAL
WIRE COLOR
PIN NO
PIN NO
WIRE COLOR
RS-232 SIGNAL
GND GRN 1 < < 1 GRN GND
TX BLK 2 < < 2 RED TX
RX RED 3 < < 3 BLK RX
RTS 4 < < 4 RTS
CTS 5 < < 5 CTS
DSR 6 < < 6 DSR
SIG GND WHT 7 < < 7 WHT SIG GND
DCD 8 < < 8 DCD
DTR 20 < < 20 DTR

© Black Box Corporation; reprinted with permission

IBM PC® Bus

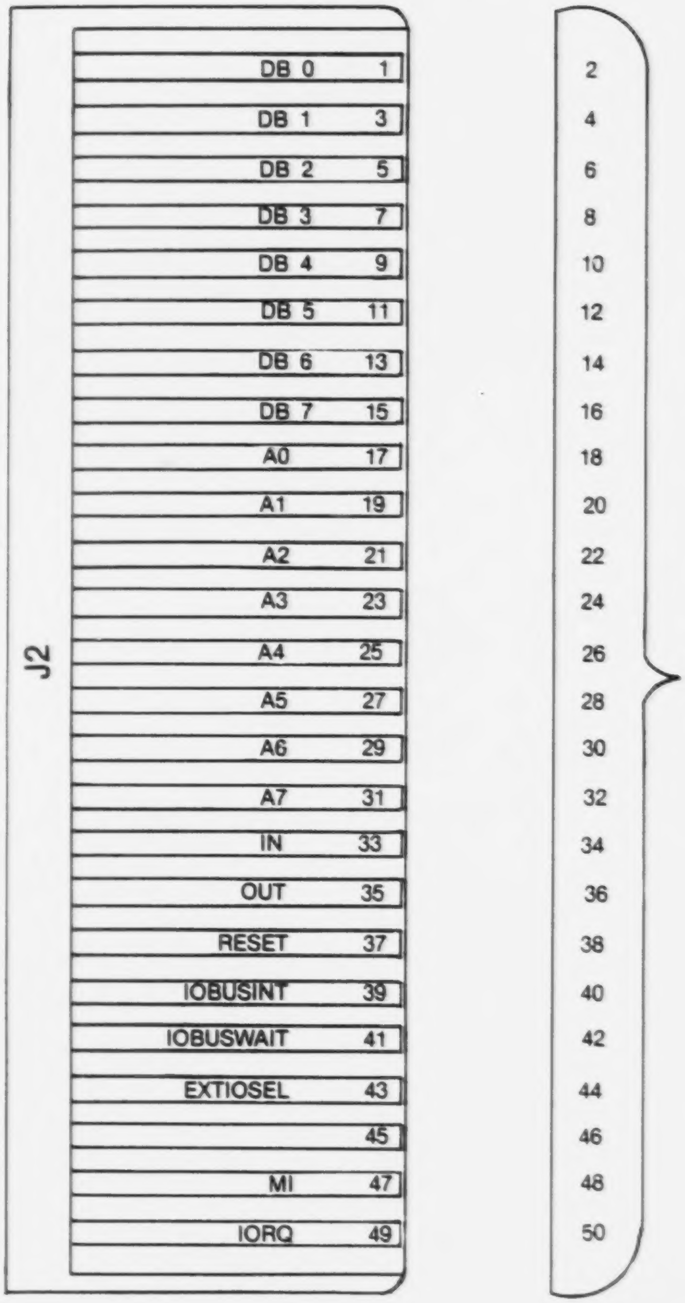
GND	B1	A1	$\overline{\text{I/O}}$ $\overline{\text{CH}}$ $\overline{\text{CK}}$
RESET DRV	B2	A2	DO
+5V DC	B3	A3	D1
IRQ2	B4	A4	D2
-5V DC	B5	A5	D3
DRQ2	B6	A6	D4
-12V DC	B7	A7	D5
NOT USED	B8	A8	D6
+12V DC	B9	A9	D7
GND	B10	A10	I/O CH RDY
MEMW	B11	A11	AEN
MEMR	B12	A12	A19
IOW	B13	A13	A18
IOR	B14	A14	A17
DACK 3	B15	A15	A16
DRQ3	B16	A16	A15
DACK 1	B17	A17	A14
DRQ 1	B18	A18	A13
DACK 0	B19	A19	A12
CLK	B20	A20	A11
IRQ 7	B21	A21	A10
IRQ 6	B22	A22	A9
IRQ 5	B23	A23	A8
IRQ 4	B24	A24	A7
IRQ 3	B25	A25	A6
DACK 2	B26	A26	A5
T/C	B27	A27	A4
ALE	B28	A28	A3
+5V DC	B29	A29	A2
OSC	B30	A30	A1
GND	B31	A31	A0

Apple II® Bus



+12V	50	1	I/O SELECT
D0	49	2	A0
D1	48	3	A1
D2	47	4	A2
D3	46	5	A3
D4	45	6	A4
D5	44	7	A5
D6	43	8	A6
D7	42	9	A7
DEVICE SELECT	41	10	A8
1ph0	40	11	A9
USER 1	39	12	A10
01	38	13	A11
Q3	37	14	A12
7M	36	15	A13
NC	35	16	A14
-5V	34	17	A15
-12V	33	18	R/W
$\overline{\text{INH}}$	32	19	NC
$\overline{\text{RES}}$	31	20	$\overline{\text{I/0}}$ $\overline{\text{STROBE}}$
$\overline{\text{IRQ}}$	30	21	$\overline{\text{RDY}}$
$\overline{\text{NMI}}$	29	22	DMA
INT IN	28	23	INT OUT
DMA IN	27	24	DMA OUT
GND	26	25	+5V

TRS-80® I/O Bus


J2
DB 0 1
DB 1 3
DB 2 5
DB 3 7
DB 4 9
DB 5 11
DB 6 13
DB 7 15
A0 17
A1 19
A2 21
A3 23
A4 25
A5 27
A6 29
A7 31
IN 33
OUT 35
RESET 37
IOBUSINT 39
IOBUSWAIT 41
EXTIOSEL 43
45
MI 47
IORQ 49
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50

All even numbered pins are grounds

BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

JOB SHEET #1 — ASSEMBLE AN RS-232 CABLE CONNECTOR

A. Tools and materials

1. Flat blade and Phillips head screwdrivers
2. Needle nose and side cutter pliers
3. Wire cutter/stripper
4. Pin insertion/extraction tool
5. Crimping tool
6. EIA RS-232-C cable as selected by instructor
7. Pins and shells (male or female)
8. Hoods
9. Screw locks (male or female)
10. Pencil and paper

B. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published and copyrighted by the Black Box Corporation and are reprinted with permission.)

1. Determine the number of conductors your cable must have

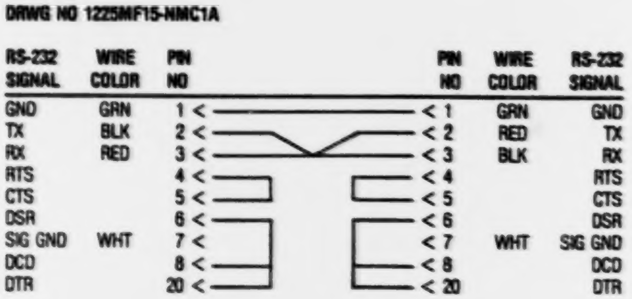
   (NOTE: Check with your instructor because the cable may have up to 25 conductors, but it is more probable that for this activity you will use 4 or 7 conductors, although other configurations use 12 or 16.)

JOB SHEET #1

2. Draw a sketch of all conductors in the connection so you'll know exactly where each conductor should go (Figure 1)

   (NOTE: Use Figure 1 as a guideline, but modify your drawing according to the cable you intend to make.)

   FIGURE 1

   DRWG NO 1225MF15-NMC1A

RS-232 SIGNAL	WIRE COLOR	PIN NO	PIN NO	WIRE COLOR	RS-232 SIGNAL
GND	GRN	1 <	< 1	GRN	GND
TX	BLK	2 <	< 2	RED	TX
RX	RED	3 <	< 3	BLK	RX
RTS		4 <	< 4		RTS
CTS		5 <	< 5		CTS
DSR		6 <	< 6		DSR
SIG GND	WHT	7 <	< 7	WHT	SIG GND
DCD		8 <	< 8		DCD
DTR		20 <	< 20		DTR

   © Black Box Corporation; reprinted with permission

3. Use the wire cutter/stripper to cut back the outer cable sheath 1" to 1 ½" (Figure 2)

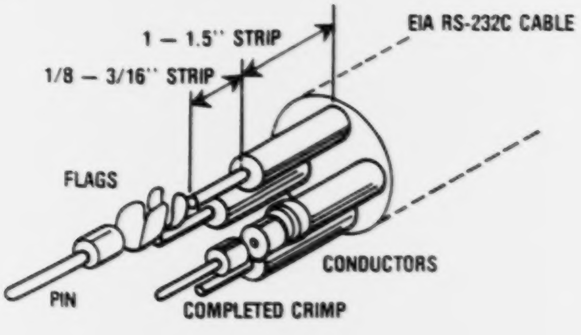
   (**CAUTION:** Select the proper gauge on the wire stripper so you won't cut into internal conductors.)

4. Strip each of the internal conductors ⅛" to 3/16" from the end (Figure 2)

5. Use a crimping tool to crimp a male or female pin/socket to each of the stripped internal conductors (Figure 2)

   (NOTE: Each pin has two crimp locations so be sure that the first crimp touches only the conductor and the second crimp goes firmly around the insulation to provide strain relief.)

   FIGURE 2

   © Black Box Corporation; reprinted with permission

JOB SHEET #1

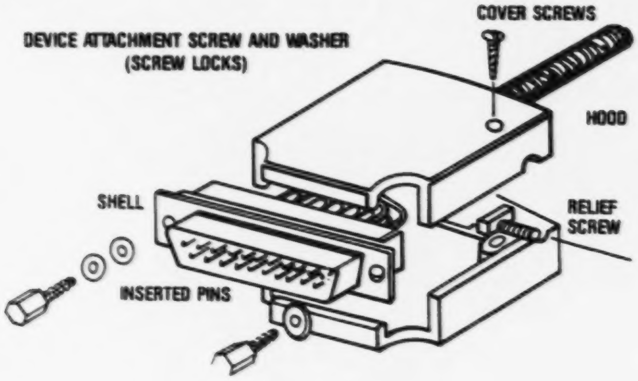
6. Use the pin insertion/extraction tool to insert the pins into the appropriate shell holes so that they will agree with your original sketch

   (**CAUTION:** The shell will be rendered useless if you inadvertently put male pins into female shells because the male pins cannot be removed, so insert male pins only into male shells and female pins into female shells.)

7. Position the completed cable-shell assembly between the two hood pieces, insert the cover screws, and screw them in only partially (Figure 3)

8. Attach the screw locks and washers and the relief screw, and then tighten all screws (Figure 3)

   FIGURE 3



© Black Box Corporation; reprinted with permission

9. Write a reference number on your initial sketch, then write that number on the label and attach the label to the finished RS-232 cable

   (NOTE: This documentation of cable makeup is a vital part of the job, and the drawing used as a guide should be filed so it can be found if the cable ever needs repairs or expansion.)

   ☐ Have your instructor check your work

10. Test the cable as directed by your instructor

11. Clean up area and return tools and materials to proper storage

BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Something that attains status through popular usage, not from formal recognition

_____b. A communications exchange accomplished with hardware

_____c. The point where two components connect within a system and/or the device used to make the connection

_____d. Specifications by which the likeness of things can be compared

_____e. Keeping one thing equal to another, a balancing

_____f. A communications exchange accomplished with software

1. Parity
2. Interface
3. Protocol
4. Defacto
5. Handshake
6. Parameters

2. Match system busses with their characteristics.

_____a. System busses create a uniform method for handling signals required by the system, make a product easy to work on, and provide upward compatibility for adding on devices with advanced circuitry

_____b. System busses handle addressing signals, data signals, and control signals for the microprocessor in its relations with other system components and for the system bus itself in its relation with application cards added to the bus

_____c. The system bus usually takes the form of a printed circuit board with edgeboard connectors designed to house the cards within the system and to transport signals from the bus to the cards

1. The concept
2. The function
3. The shape

TEST

3. Differentiate between types of system busses by placing an "X" beside the definition of a microcomputer bus.

_____a. A system bus designed with addressing signals, data signals, and control signals to manage operations of a microcomputer system

_____b. A system bus designed for the specific purpose of interfacing scientific or other specialized instruments with a control system

4. Differentiate between types of application cards for system busses by placing an "X" beside the definition of a slave card.

_____a. Any card that has on board a microprocessor or any other capability for controlling the bus

_____b. Any card that does not have bus control capability

5. List four signal groups in a system bus.

a. ____

b. ____

c. ____

d. ____

6. Complete the following statements concerning using the system bus as a troubleshooting tool by inserting the word(s) that best completes each statement.

a. The system bus provides ____________ ____________ for a troubleshooter to check, test, and otherwise troubleshoot a system

b. The signals from the system bus consist of ____________ the major electrical signals available to the system and can be selectively used to evaluate specific parts of a system

c. An easy technique for gaining access to the system bus is to use a "____________ ____________ ____________" which can be purchased commercially or easily put together from materials available at almost all electronic shops

TEST

7. Complete the following statements concerning typical system busses by inserting the word(s) that best completes each statement.

   a. Apple II® bus — Apple refers to their bus as a "_____________ _____________"

   b. TRS-80® bus — The only external pin connections available for general use are at the _____________ port connector

   c. IBM PC® bus — A valuable bus for troubleshooters to learn because of the _____________ of the IBM product line and the use of a compatible bus by many other manufacturers seeking to produce IBM-compatible products

8. Complete the following statements concerning the IBM PC bus by inserting the word(s) or figure(s) that best complete each statement.

   (NOTE: Refer to Transparency 1.)

   a. A bus with _____________ pin connectors

   b. Is labeled with an _____________ and _____________ side

   c. All A's and B's are _____________ each other from 1 to 31, that is, A1 is _____________ B1 and on to A31 which is _____________ B31

   d. Address lines A0 through A19 have a _____________ correlation to pins #A31 through #A12, in other words, address line zero is at pin #A31 and address line nineteen is at pin #A12

   e. Data lines D0 through D7 are in _____________ starting at pin #A2 and going through pin #A9 respectively

   f. This is a popular bus and a good one for troubleshooters to learn because it is a "_____________" standard bus which promises to be common in the microcomputer industry

9. Complete the following statements concerning power supply pins on the IBM PC bus by inserting the figure(s) that best completes each statement.

   (NOTE: Refer to Transparency 1.)

   a. +5V is found on two pins, #_____________ and #_____________

   b. −5V is found on only pin #_____________

   c. +12V is found only on pin #_____________

   d. −12V is found on only pin #_____________

   e. Gnd is found on three pins, #_____________, #_____________, and _____________

TEST

10. Complete the following statements concerning timing signals on the IBM PC bus by inserting the word(s) or figure(s) that best complete each statement.

(NOTE: Refer to Transparency 1.)

a. Pin #B30 labeled OSC is the ____________ signal coming into the system at 14.31818 MHz

b. Pin #____________ labeled ____________ is the 4.77 MHz clock signal

11. Complete the following statements concerning control signals on the IBM PC bus by inserting the word(s) or figure(s) that best completes each statement.

(NOTE: Refer to Transparency 1.)

a. Pin #B2 labeled RESET DRV is the ____________ ____________ signal that is held high during power on reset sequence

b. Pin #B28 labeled ALE is the ____________ ____________ ____________ signal which goes active just prior to the address being valid and goes inactive when the address bus is valid

c. Pin #A1 labeled $\overline{\text{IO CH CK}}$ is the input/output channel check that checks all interface cards added to the bus and reports any ____________ conditions back to the 8088 microprocessor

d. Pin #A10 labeled I/O CH RDY is the input/output channel signal that extends the bus cycle timing as much as 21 nanoseconds to accommodate ____________ I/O devices

e. Pin #B14 labeled IOR is the standard output signal from the 8288 bus ____________ ____________

f. Pin #B13 labeled IOW is the ____________ signal from the 8288 bus controller

g. Pin #B11 labeled MEMW is the ____________ ____________ signal that comes from the 8288 bus controller and causes information on the system data bus to be written into memory

h. Pin #B12 labeled MEMR is the ____________ ____________ signal that signals information should be transferred from memory to the system data bus

12. Complete the following statements concerning DMA control signals on the IBM PC bus by inserting the word(s) or figure(s) that best completes each statement.

(NOTE: Refer to Transparency 1.)

a. Pin #B18 labeled DRQ1, pin #B26 labeled DRQ2, and pin #B16 labeled DRQ3 are the three DMA request lines that permit a device to transfer information between memory and that device ____________ ____________ ____________ ____________ ____________

TEST

b. Pin #B19 labeled DAK0, pin #B17 labeled DAK1, pin #B26 labeled DAK2, and pin #B15 labeled DAK3 are all signals issued by the 8237 DMA controller chip to indicate that a DRQ _____________ _____________ _____________

c. Pin #A11 labeled AEN is an address enable signal put out by the DMA controller to indicate to other parts of the system that a DMA transfer is in process and to _____________ _____________ the bus because it's _____________

d. Pin #B27 labeled T/C is the terminal count signal issued by the DMA controller to indicate that one of the DMA channels has reached its programmed _____________ of cycles

13. Complete the following statements concerning general information about the Apple II bus by inserting the word(s) or figure(s) that best complete each statement.

(NOTE: Refer to Transparency 2.)

a. Apple refers to its bus as a "_____________ _____________ _____________"

b. It is a 50-pin bus designed to accept _____________ _____________ with edge connectors

c. Has _____________ address lines and _____________ data lines and has some control signals connected through buffering components directly with the microprocessor

d. As the name peripheral connector implies, the bus treats each _____________ _____________ as a peripheral location

14. Complete the following statements concerning timing signals on the Apple II bus by inserting the word(s) or figure(s) that best completes each statement.

(NOTE: Refer to Transparency 2.)

a. Pin #36 is the 7 MHz clock that comes from the oscillator and is divided down to give the 3.58 MHz _____________ _____________

b. Pin #_____________ is called the Q3 signal which is a 2 MHz clock signal used for various activities around the system

c. Pin #38 is the _____________ clock or the microprocessor clock that does the addressing

d. Pin #40 is the _____________ clock which is a signal from the oscillator that serves as an input frequency for the microprocessor

15. Complete the following statements concerning power supply pins on the Apple II bus by inserting the figure(s) that best completes each statement.

(NOTE: Refer to Transparency 2.)

a. Pin #25 is _____________

b. Pin #26 is _____________

TEST

c. Pin #33 is ____________

d. Pin #34 is ____________

e. Pin #50 is ____________

16. Complete the following statements concerning control and line signals on the Apple II bus by inserting the word(s) or figure(s) that best completes each statement.

(NOTE: Refer to Transparency 2.)

a. Pin #1 labeled I/O SELECT is the signal that the microprocessor uses to select a particular ____________ location

b. Pin #2 through #17 are the locations of the ____________ address lines which are numbered in order with A0 being at pin #2 and A15 being at pin #17

c. Pin #18 labeled R/W is the ____________ ____________/____________ signal which goes high to read and low to write and is timed by the system clock so that it becomes valid when the address bus does

d. Pin #20 labeled $\overline{\text{I/ O STROBE}}$ selects addresses between hex C800 and hex CFFF, and these are areas specified as I/O ____________ areas

e. Pin #21 labeled $\overline{\text{RDY}}$ is the signal that goes to the ready line on the microprocessor, and will ____________ the microprocessor when it is low during the $\phi 1$ clock

f. Pins #42 through #49 are the locations of the ____________ data lines which are numbered in reverse with D7 being at pin #42 and D0 being at pin #49

g. Pin #41 labeled $\overline{\text{DEVICE SELECT}}$ is a ____________ going signal that indicates that the address bus is holding the address that contains the slot number plus the hex 8 within its address span

17. Solve the following problems concerning DMA and interrupt signals on the Apple II bus.

(NOTE: Refer to Transparency 2.)

a. In order for direct memory access to work, the address bus on the microprocessor has to be disabled, so how is this accomplished on the bus?

Solution ____

____

b. How is input from higher priority devices taken and how is priority output handled?

Solution ____

____

TEST

18. Solve the following problem concerning color signals on the Apple II bus.

Pins #19 and #35 are the color signal control pins, but on what edge card connector are they found?

Solution ______________________________

19. Complete the following statements concerning general information about the TRS-80 bus by inserting the word(s) that best completes each statement.

a. Unlike other system busses, this bus is different because it is essentially an ____________ ____________ with almost no direct relationship to the microprocessor

b. The I/O port does have buffered ____________ to the data bus and buffered ____________ from address lines A0 through A7

c. The bus contains an 8-bit ____________ printer port with a centronics handshake

d. Because of its structure, the TRS-80 bus is not much use as a troubleshooting tool unless a malfunction occurs when an ____________ is attached

20. Locate data and address line signals on the TRS-80 bus by completing the following statements.

(NOTE: Refer to Transparency 3.)

a. ____________ through ____________ are found in order on pins #1, #3, #5, #7, #9, #11, #13, and #15

b. Address lines ____________ through ____________ are found in order on pins #17, #19, #21, #23, #25, #27, #29, and #31

21. Complete the following statements concerning control signals on the TRS-80 bus by inserting the word(s) or figure(s) that best completes each statement.

(NOTE: Refer to Transparency 3.)

a. Pin #33 is an ____________ control pin

b. Pin #35 is an ____________ control pin

c. Pin #39 labeled IOBUSINT is an ____________

d. Pin #41 labeled IOBUSWAIT is an incoming signal that tells the system ____________ ____________ ____________

e. Pin #43 labeled EXTIOSEL connects the microprocessor external I/O device select pin and it will remain high until pulled low by an external device that ____________ the 8 data lines

TEST

f. Pin #49 is an I/O request pin that goes ____________ to the ____________

g. All even numbered pins are ____________ pins and pin #45 is ____________ ____________

22. Solve the following problem concerning electrical signals on the TRS-80 bus.

There is an apparent clock problem with a TRS-80 system and a technician is trying to check it out on the system bus, so what's the problem and how should it be solved?

Solution ____

____

23. Match other types of busses with their characteristics.

______a. An industrial bus designed by Motorola for use with Motorola microprocessor parts and specifically the Motorola MCS68000

______b. An instrumentation bus designed by Hewlett-Packard to make computer products compatible with electronic and scientific instruments

______c. This bus is the only true 16-bit microcomputer bus, but the bus is no longer in use since the company withdrew from the microcomputer market

______d. This bus was designed specifically for use with the Z-80 microprocessor, is now used only on some single board products and is still popular with hobbyists, but not used in numbers in the microcomputer market

______e. This bus is still popular with hobbyists, but is not a bus that technicians will often confront in troubleshooting

______f. A bus not widely used in microcomputers, but a valuable bus for troubleshooters to learn because it is an excellent bus design and will help a troubleshooter better understand other bus structure

1. TI
2. IEEE 488
3. Zilog
4. VME
5. Intel SBC Multibus
6. S-100

24. Complete the following statements concerning the RS-232-C standard by inserting the word(s) that best completes each statement.

a. The RS-232-C is a communications standard written by the Electronics Industry Association and recommended as a guide for communicating ____________ information

TEST

b. The RS-232 is specifically a standard for communicating ____________ information in ____________ form

c. The RS-232 standard has two very important elements:

1) The electrical parameters involved, including the voltage levels that are acceptable, and specific pin connections that must agree with the ____________ standard

2) The communications ____________ involved, including handshaking and the high and low bit signals used to indicate the beginning and end of the ASCII data word being transmitted

25. Complete the following statements concerning electrical parameters for the RS-232 standard by inserting the word(s) or figure(s) that best completes each statement.

a. RS-232 voltages are not compatible with ____________ logic

b. To comply with the RS-232 standard, voltages must range between ____________ and ____________ and ____________ and ____________

c. RS-232 logic 1 can be any voltage between −3V and ____________

d. RS-232 logic 0 can be any voltage between +3V and ____________

e. The most common voltages used with RS-232 are +5V and −5V and +12V and −12V because these are the voltages commonly available from ____________ ____________ ____________ ____________

26. Arrange in order typical steps in an RS-232 communication by placing the correct sequence number in the appropriate blank.

_____a. The next bit transmitted will be the 8th bit or the parity bit which serves as an error checking bit, and may be high or low in accordance with the parity required

_____b. Following the parity bit will be the stop bit which will be at logic 1 or high

_____c. The signal will stay low for one bit time and this is referred to as the start bit

_____d. Following the start bit, there will be seven data bits at the same time frame and all seven bits of information will be in ASCII code

_____e. A transmission is complete when it contains one start bit, seven data bits, and one or two stop bits

_____f. After the stop bit(s) the machine can idle at logic high until it goes low for one bit time which will start the transmission cycle over again

_____g. In order to begin a serial communication in the standard, the logic level must be high

_____h. At the start of a character transmission, the logic level must go low for one time period

TEST

27. Complete the following statements concerning parity and how it works by inserting the word(s) that best completes each statement.

    a. Whether there is parity or no parity must be set up as part of the communications protocol, and if there is parity, it must either be:

        1) __________ parity

        2) __________ parity

    b. Since even parity means that a word must contain an even number of bits, any word that contains an odd number of bits must be modified:

        1) A parity bit must be added to even the numbers and make the signal __________ __________ before transmission

        2) The even number of bits is then checked for at the other end of the communications by the __________ __________ __________

    c. Since odd parity means that a word must contain an odd number of bits, any word that contains an even number of bits must be modified:

        1) A parity bit must be added to make the numbers odd and make the signal go __________ before transmission

        2) The odd number of bits is then checked for at the other end of the transmission by the __________ __________ __________

    d. Parity can be generated by readily available __________ and __________ mechanisms

28. Complete the following statements concerning mechanical specifications for the RS-232 by inserting the word(s) or figure(s) that best completes each statement.

    a. The __________ configuration complete with __________ requirements for specific pin locations are written into the standard

    b. The standard requires a "__________" type connector of __________ pins arranged in two rows with __________ pins in one row and __________ pins in one row

    c. Pin numbers are __________ __________ __________ __________ __________ around the __________ connector to avoid errors in identifying pin numbers

    d. Among the EIA pins specifications, the following are very important primary pins:

        1) Pin #2 — __________ data

        2) Pin #3 — __________ data

        3) Pin #4 — __________ to send

TEST

4) Pin #5 — ____________ to send

5) Pin #6 — Data ____________ ready

6) Pin #7 — ____________ ____________ for signal

7) Pin #20 — Data ____________ ready

e. Pins #2 and #3 control the ____________ of data on the bus

f. Pins #4, #5, and #6 establish ____________ and also accomplish a ____________ arrangement for sending information back and forth

g. It is a common practice with serial printers to use only pins #____________, #____________, and #____________

h. When protocol requires a ____________ arrangement, pins #4, #5, #6, and #20 are used

i. A full bidirectional communications link will require not only primary pins, but also the following secondary pins:

1) Pin #12 — Secondary ____________ line signal detector

2) Pin #13 — Secondary ____________ to send

3) Pin #14 — Secondary ____________ data

4) Pin #16 — Secondary ____________ data

5) Pin #19 — Secondary ____________ to send

29. Solve the following problems concerning other EIA pin specifications for the RS-232.

a. Since a modem is a piece of data communications equipment that will both send and receive data, can an RS-232 interface be used to hook one up, and if so, why will it work?

Solution ____

____

b. If a communications format called for a bell to ring at a given point in a transmission, could an RS-232 interface handle the job, and if so, how?

Solution ____

____

TEST

30. Select true statements concerning RS-232 relationships with DCE and DTE devices by placing "X" in the appropriate blanks.

_____a. Data communications equipment devices, like modems, have the capacity for bidirectional communications

_____b. Data terminal equipment devices, like printers and video displays, are usually unidirectional and receive but do not send information

_____c. Although DTE devices are unidirectional, it is not uncommon to find a handshake on a DTE device

31. Complete the following statements concerning the centronics standard by inserting the word(s) or figure(s) that best completes each statement.

a. The centronics standard is actually a "____________" standard used for communicating digital information in parallel form

b. The centronics connector is a ____________ ____________ device used most frequently for connecting parallel printers to microcomputers and may be made with a round cable which is usually soldered or a ribbon cable or the solderless clamp-on type

c. A centronics cable usually leaves a microcomputer through a ____________ ____________ connector on the microcomputer's parallel printer port

d. A centronics cable usually enters the printer through a ____________ ____________ centronics male connector which inserts into the ____________ ____________ female centronics receptacle built into the printer

32. Solve the following problem concerning pin arrangements for the centronics connector.

Pin #2 is labeled ACK to indicate acknowledge, so what does it acknowledge?

Solution ____

____

33. Arrange in order typical steps in a centronics communication by placing the correct sequence number in the appropriate blank.

_____a. Upon a command from the microcomputer, the strobe signal goes low and data is strobed onto the eight parallel data lines simultaneously

_____b. At the time the printer receives the data, it will then send a low going acknowledge signal back to the microcomputer

_____c. As soon as the acknowledge signal is received by the microcomputer, the microcomputer knows it can strobe new data to the printer and the cycle will be repeated

_____d. The strobe alerts the printer that data is on the line and the printer accepts the information

TEST

34. Complete the following statements concerning types of cables used with RS-232 and centronics standards by inserting the word(s) that best completes each statement.

    a. ____________ cables may be used and usually have ____________ connections

    b. ____________ ____________ cables may be used and these are usually ____________ with ____________ ____________ connections

    c. All peripheral cable connections are ____________, and for that reason building both RS-232 and centronics cables is sometimes ____________ ____________ troubleshooting and repair work

35. Complete the following statements concerning cable assembly techniques by circling the word(s) that best completes each statement.

    a. Soldering cables is a traditional technique, but cable quality depends on the (**attitude, soldering skill**) of the technician, and soldered cables are (**difficult, fairly easy**) to service or change in the field

    b. The pin insertion technique is much easier for the (**advanced technician, beginner**), the results are more (**certain, consistent**) than with soldered cables, and the cables are (**easier, more difficult**) to service or change in the field

36. Complete the following statements concerning special tools for cable assembly by inserting the word(s) that best completes each statement.

    a. ____________ ____________/____________ for properly removing insulation from cables and connectors

    b. ____________ ____________/____________ tool to insert or remove crimp-type pins in D series connector shells

    c. ____________ tool to ____________ the flags or holding flanges on pins

37. Complete the following list of special materials for cable assembly by inserting the word(s) that best completes each statement.

    a. Male or female ____________/____________

    b. Two-part hood or ____________

    c. Screw ____________ or attachment screws and washers

    d. Strain relief screw or ____________

TEST

38. Arrange in order the steps in documenting cable assemblies by placing the correct sequence number in the appropriate blank.

_____a. When the assembly is completed, label it with the reference number of the drawing

_____b. File the original drawing or sketch along with its reference ID so it can be found if the cable needs servicing or changing

_____c. Sketch or make a formal drawing of the pin connections in the assembly

_____d. Identify the basic cable type, other important elements in the assembly, then give the drawing a reference number

(NOTE: If the following activity has not been completed prior to the test, ask your instructor when it should be completed.)

39. Demonstrate the ability to assemble an RS-232 cable connector. (Job Sheet #1)

BUSSES, PROTOCOLS, AND HANDSHAKES
UNIT V

ANSWERS TO TEST

1. a. 4
   b. 5
   c. 2
   d. 6
   e. 1
   f. 3

2. a. 1
   b. 2
   c. 3

3. a

4. b

5. a. Power supply voltages
   b. Data signals
   c. Address signals
   d. Control signals

6. a. Easy access
   b. All
   c. Bus extender card

7. a. Peripheral connector
   b. I/O
   c. Popularity

8. a. 62
   b. A, B
   c. Opposite, opposite, opposite
   d. Backward
   e. Order
   f. Defacto

9. a. B3, B29
   b. B5
   c. B9
   d. B7
   e. B1, B31, B10

10. a. Oscillator
    b. B20, CLK

ANSWERS TO TEST

11. a. Reset driver
b. Address latch enable
c. Error
d. Slow
e. Controller card
f. I/O
g. Memory write
h. Memory read

12. a. Without intervention of the microprocessor
b. Has been honored
c. Stay off, busy
d. Limit

13. a. Peripheral connector bus
b. PC cards
c. 16, 8
d. Pin connection

14. a. Color signal
b. 37
c. $\phi 1$
d. $\phi 0$

15. a. +5V
b. Gnd
c. −12V
d. −5V
e. +12V

16. a. Peripheral
b. 16
c. Buffered read/write
d. Control
e. Halt
f. 8
g. Low

17. a. At pin #22 with a low going DMA signal
b. Through pin #27, DMA IN, and pin #24, DMA OUT

18. #7

19. a. I/O port
b. Input, output
c. Parallel
d. I/O device

20. a. D0, D7
b. A0, A7

ANSWERS TO TEST

21. a. Input
    b. Output
    c. Interrupt
    d. When to wait
    e. Enables
    f. Back, microprocessor
    g. Ground, not used

22. There are no clock signals on the TRS-80 bus so troubleshoot the problem at the microprocessor

23. a. 4
    b. 2
    c. 1
    d. 3
    e. 6
    f. 5

24. a. Digital
    b. Digital, serial
    c. 1) Written
       2) Protocol

25. a. TTL
    b. −3V, −15V, +3V, +15V
    c. −15V
    d. +15V
    e. A system power supply

26. a. 5
    b. 6
    c. 3
    d. 4
    e. 7
    f. 8
    g. 1
    h. 2

27. a. 1) Even
       2) Odd
    b. 1) Go high
       2) Parity checking bit
    c. 1) Low
       2) Parity checking bit
    d. Hardware, software

ANSWERS TO TEST

28. a. Mechanical, electrical
    b. D, 25, 13, 12
    c. Impressed into the protective casing, D
    d. 1) Transmitted
       2) Received
       3) Request
       4) Clear
       5) Set
       6) Common ground
       7) Terminal
    e. Direction
    f. Protocol, handshake
    g. 2, 3, 7
    h. Handshaking
    i. 1) Receive
       2) Clear
       3) Transmitted
       4) Received
       5) Request

29. a. Yes because the RS-232 has transmit and receive signals specifically for serial communications with modems
    b. Yes because the RS-232 has a ring indicator which can be interfaced to make a bell ring

30. a, b, c

31. a. Defacto
    b. 36-pin
    c. DB 25
    d. 36-pin, 36-pin

32. The handshake

33. a. 1
    b. 3
    c. 4
    d. 2

34. a. Round, soldered
    b. Flat ribbon, solderless, clamp-on
    c. Expensive, part of

35. a. Soldering skill, difficult
    b. Beginner, consistent, easier

ANSWERS TO TEST

36.
  a. Wire cutter/stripper
  b. Pin insertion/extraction
  c. Crimping, crimp

37.
  a. Pins/sockets
  b. Shell
  c. Locks
  d. Device

38.
  a. 3
  b. 4
  c. 1
  d. 2

39. Performance competency evaluated according to procedures in the job sheet

GENERIC TROUBLESHOOTING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss initial steps in advanced troubleshooting and the logical order of systematic troubleshooting. The student should also be able to list graphic aids used in advance troubleshooting. These competencies will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to generic troubleshooting with their correct definitions.
2. Select true statements concerning first rules for advanced troubleshooting.
3. Complete a list of troubleshooting preliminaries.
4. Complete statements concerning the rationale and order of systematic troubleshooting.
5. Select true statements concerning other elements of systematic troubleshooting.
6. Complete a list of habits that promote better troubleshooting.
7. Complete statements concerning graphic materials and their uses in troubleshooting.
8. Select true statements concerning block diagrams and their characteristics.
9. Complete statements concerning schematics and their characteristics.
10. Select true statements concerning other graphic aids for troubleshooting.

OBJECTIVE SHEET

11. Complete statements concerning schematics and troubleshooting guides.
12. Read and interpret parts of a Computerfacts™ schematic. (Assignment Sheet #1)
13. Demonstrate the ability to cut and desolder pins and remove a chip from a printed circuit board. (Job Sheet #1)

GENERIC TROUBLESHOOTING
UNIT VI

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information, assignment, and job sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheet.

F. Discuss assignment and job sheets and demonstrate the procedures outlined in the job sheet.

G. Review the procedures for troubleshooting decoders, logic gates, RC networks and other circuitry associated with system components.

H. Have a Computerfacts™ available for students to examine and discuss, and impress upon students the importance of knowing how to properly read and interpret schematics and other graphic aids for troubleshooting.

I. Examine the five units of instruction that follow this one and order the Computerfacts™ you will need for those units of instruction.

(NOTE: The Computerfacts™ required for troubleshooting five popular brands of microcomputers are available from MAVCC at special educational discounts, so read the introductory materials to this text for ordering procedures.)

J. Review soldering and desoldering techniques and discuss the need for wearing safety glasses when working with IC's and other components that have the potential to explode when subjected to overheating.

K. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Transparency masters

   1. TM 1 — Block Diagram

   2. TM 2 — Schematics

CONTENTS OF THIS UNIT

D. Assignment Sheet #1 — Read and Interpret Parts of a Computerfacts™ Schematic

E. Answers to assignment sheet

F. Job Sheet #1 — Cut and Desolder Pins and Remove a Chip from a Printed Circuit Board

G. Test

H. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Brenner, Robert C. *IBM PC Troubleshooting and Repair Guide.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1985.

B. Johnston, Chris. *The Microcomputer Builder's Bible.* Blue Ridge Summit, PA 17214: Tab Books Inc., 1982.

C. *SAMS Computerfacts™ CC5, COMPUTER: Atari 400™*. Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1985.

D. *SAMS Computerfacts™ CSCS2 Computer: IBM® PC5150.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1985.

E. Stephenson, John, and Bob Cahill. *How to Maintain and Service Your Small Computer.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1983.

F. *The IC Troubleshooters, New Techniques of Digital Troubleshooting, Applications Note 163-2.* Palo Alto, CA 94304: Hewlett-Packard, No date.

G. Zumchak, Eugene. *Microcomputer Design and Troubleshooting.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1982.

GENERIC TROUBLESHOOTING
UNIT VI

INFORMATION SHEET

I. **Terms and definitions**

A. Burn-in time — A period after repairs are completed when a system is operated for an extended time in order to prove replacement components and total system functions

B. Diagnostics — Software designed to check system functions

C. Generic troubleshooting — Troubleshooting routines that apply generally to almost all microcomputers

D. Known good component — A new component made by a reputable manufacturer or a working component taken from a system that is operating properly

E. Systematic troubleshooting — The logical arrangement of troubleshooting routines so that elements common to overall operation are checked first so that other problems can be isolated with speed and accuracy

F. Shotgunning — The mass replacement of ROM, RAM, or other components in the hopes of quickly correcting a malfunction without having to troubleshoot a system

II. **First rules for advanced troubleshooting**

A. Always run diagnostic software when it is available and when a microcomputer or disk drive is operational to the point that it will run the diagnostics

B. Use data or logic analyzers whenever they are available because they provide accurate information and permit troubleshooting at critical points in a microcomputer system

C. When a system is inoperative or experiencing an intermittent problem, take time to plan a systematic troubleshooting scheme, and rely on routines that have been proven effective for the same or similar problems

III. **Troubleshooting preliminaries**

A. Make sure the proper paperwork accompanies the equipment

(NOTE: Paperwork requirements vary from one repair facility to another, but make sure you know what documents should be with the equipment, and if they are not, report it to a responsible party.)

B. Evaluate written descriptions of the problem according to the reliability of the submitting party

(NOTE: Most equipment is shipped to repair centers by board swappers whose abilities may range from excellent to poor, so base submitted evaluations on the quality of the people who do business with the company.)

INFORMATION SHEET

C. Make sure the equipment suffered no shipping damage

D. Once the cover or case is removed from a piece of equipment, make a quick sensory check for burned or broken parts and loose cables and connectors

E. Attempt to duplicate the problem described by the submitting party

IV. **The rationale and order of systematic troubleshooting**

A. The power supply should always be checked FIRST because it is the source of operating voltages for the entire system and must be functional before other components can be checked

B. The kernel system controls many operational activities and should be checked SECOND

1. Supply voltages to the microprocessor must be correct or there can be no control functions

2. The system clock must be working properly or addressing and data transfer cannot take place

3. Interrupts and control signals must be at the proper logic level or the microprocessor functions will stop

4. There must be activity on the address and data busses for the transport and exchange of control information

C. Because it also serves control functions, system ROM should be checked THIRD

D. Because it is the storehouse of information the system works with, system RAM should be checked FOURTH

E. Because they connect the microcomputer with the outside world, I/O functions should be checked FIFTH

V. **Other elements of systematic troubleshooting**

A. Check and reseat IC's as required, and remember that sometimes perplexing problems have been traced to bad connectors, loose or faulty sockets, and similar mechanical problems

B. Develop a knack for backtracing with a current tracer because once proper voltages are verified at the power supply, backtracing is an effective technique for isolating line breaks

C. Pay attention to the circuitry associated with specific components because problems with single transistors, resistors, and capacitors can cause major malfunctions or contribute to perplexing intermittents

INFORMATION SHEET

D. Substitute known good components for verified or suspected faulty components only when needed or at a time when the substitution affords the quickest way to solve the problem

Example: When there is no bus activity evident on a microprocessor, it needs to be replaced, and after voltages have been verified and ROM or RAM chips still seem to malfunction, the quickest way around the problem is to substitute known good ROM or RAM

E. Pay constant attention to improving your soldering and desoldering skills for there will be times when these skills are needed to solve a problem

(NOTE: Job Sheet #1 outlines a chip removal procedure that employs desoldering skills.)

VI. Habits that promote better troubleshooting

A. Take time to reevaluate your troubleshooting at logical points in the routine and do not continue until you know that you have executed a given routine properly

B. Take notes when you solve unusual or difficult problems and if there are no files where you work, start your own equipment "history" files and add to them from personal experience

C. Make a habit of using diagrams and schematics because they can save you a great deal of time

D. Be alert for problems in graphic materials you use, and when you find a problem in a schematic or diagram, CORRECT IT so you won't run into the same problem again

E. Post technical updates (or copies of them) where they can be clearly seen and referenced the next time a piece of equipment with a similar problem comes in for repair

F. Once equipment is repaired, run it for an appropriate burn-in period to make sure the repair is okay under continued operating conditions

VII. Graphic materials and their uses in troubleshooting

A. As with blueprints in the building trades, graphic materials which provide representative pictorial guidance are essential for efficient microcomputer troubleshooting

B. Graphic materials range in sophistication from simple block diagrams to intricate system schematics, and referencing the proper graphic material is not only time saving, it is frequently mandatory

INFORMATION SHEET

VIII. **Block diagrams and their characteristics** (Transparency 1)

A. Block diagrams are used to show relationships between large groups of circuitry or entire microcomputer subsystems

B. Block diagrams are so called because the shapes used to depict components in a system are rectangular spaces labeled to indicate component names

C. The representative components in a block diagram are usually connected by lines to indicate the direction of signal flow:

1. Wide double lines usually represent busses
2. Single lines usually represent control signals or power connections

D. A single arrow on a block diagram usually traces the origin and destination of a signal and an arrow on each end of a line indicates bidirectional information flow such as with data or I/O busses

IX. **Schematics and their characteristics** (Transparency 2)

A. Anyone planning to work at advanced level troubleshooting with microcomputers must have schematics available and know how to use them

B. Schematics for microcomputers are designed for troubleshooting and will almost always include:

1. Part numbers
2. Pin numbers
3. Voltage and current requirements
4. Waveforms pictorially presented so they can be compared with test waveforms screened on an oscilloscope
5. Standard electronic symbols for resistors, capacitors, transistors, IC's, and other components

C. Although some component troubleshooting can be done without a schematic, troubleshooting a complete system without a schematic would be an adventure in wasted time

D. Using a schematic properly will reduce troubleshooting time and keep repair costs down by eliminating the expensive practice of shotgunning

INFORMATION SHEET

X. **Other graphic aids for troubleshooting**

A. PC board diagrams are useful troubleshooting aids especially when they have overlaid numbering showing where test points are located or where certain components are located on the back side of the board

B. PC board diagrams are sometimes needed to help identify circuits used on the PC board

Example: The memories of larger systems may have card after card of the same memory devices and the devices are identical in appearance but different functions would be difficult to spot without a reliable reference

C. Some helpful manufacturers have identification information silk-screened onto their boards, but without this, a troubleshooter needs the help of a diagram

D. Line diagrams of specific components are especially useful because these are usually drawn to scale, well labeled, and frequently treat components such as connectors and support devices that get no attention elsewhere

E. Line diagrams are also used for pinouts and to depict waveforms generated by clock and timing signals

F. Bubble diagrams are useful for graphically presenting complex troubleshooting routines which branch out from a starting place into subroutines then back to a main routine

XI. **Schematics and troubleshooting guides**

A. Another excellent source of schematics and troubleshooting guidelines is Computerfacts™

(NOTE: Computerfacts is a trademark of the publisher, Howard W. Sams and Co., Inc., of Indianapolis, Indiana.)

B. Computerfacts are available for most of the popular brands of microcomputers, disk drives, printers, and video display units

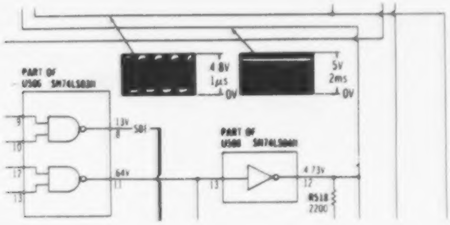
C. Major components in a typical Computerfacts include:

1. A list of preliminary service checks

INFORMATION SHEET

2. Schematics including standard notations for waveforms, voltages, and stage identification (Figure 1)

FIGURE 1


PART OF
U506 SN74LS03N
4.8V
1μs
0V
5V
2ms
0V
9
10
12
13
13V
8
58I
64V
11
PART OF
U506 SN74LS04N
13
4.73V
12
R518
2200

3. Step by step troubleshooting guides

4. A component by component parts list (Figure 2)

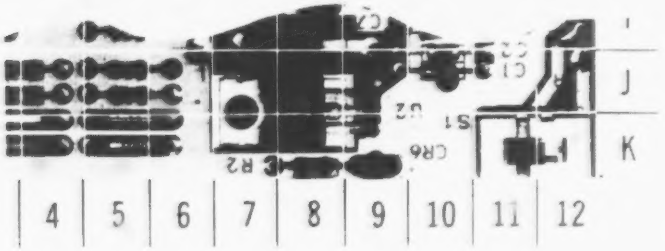
FIGURE 2

SEMICONDUCTORS (Select replacement for best results)

ITEM No	TYPE No	MFGR PART No	REPLACEMENT DATA						
			ECG PART No	GENERAL ELECTRIC PART No	MOTOROLA PART No	NTE PART No	RCA PART No	WORKMAN PART No	ZENITH PART No
D102	1SS53	1149-2576	ECG519	GE-514	1N4935	NTE519	SK9091/177	WEP925/519	103-131
D103	1N60FM	1149-2527	ECG109	1N60		NTE109	SK3088	WEP134/109	103-29001
D201	1N4004GP	1201-4205	ECG116	GE-504A	1N4004	NTE116	SK3312	WEP157	212-76-02
D501 thru D503	1SS53	1149-2576	ECG519	GE-514	1N4935	NTE519	SK9091/177	WEP925/519	103-131

5. Excellent photographs with map-type grid references to help locate components quickly (Figure 3)

FIGURE 3


C2
C3
C1
U2
S1
CR6
R2
L1
I
J
K
4
5
6
7
8
9
10
11
12

INFORMATION SHEET

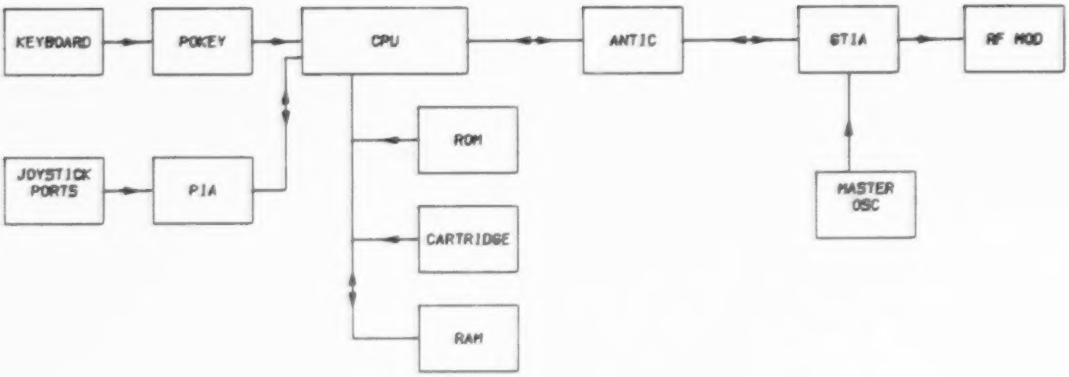
6. A logic chart to assist in finding faulty circuitry with a logic probe (Figure 4)

FIGURE 4

LOGIC

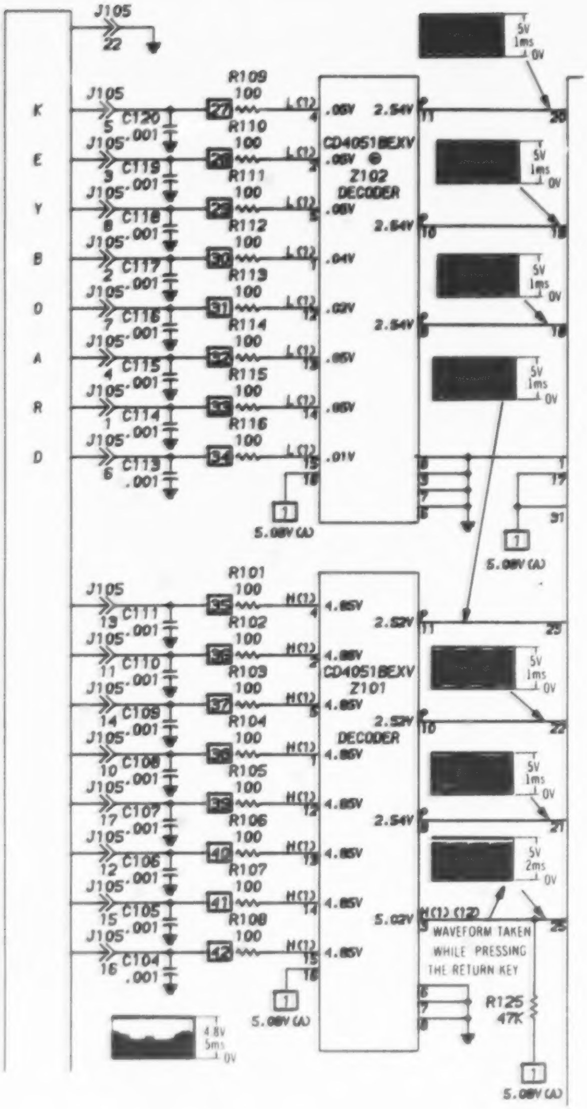
PIN NO.	IC U100	PIN NO.	IC U100	PIN NO.	IC U102	IC U103	IC U104	IC U105	IC U106	IC U107	IC U108	IC U109
1	P	21	P	1	L	L	L	L	L	L	L	L
2	P	22	P	2	P	P	P	P	P	P	P	P
3	P	23	P	3	H	H	H	H	H	H	H	H

Block Diagram


KEYBOARD
POKEY
CPU
ANTIC
GTIA
RF MOD
JOYSTICK PORTS
PIA
ROM
CARTRIDGE
RAM
MASTER OSC

Courtesy Howard W. Sams & Co., Inc.

Schematic


J105
22
KEYBOARD
J105
5
C120
.001
R109
100
27
L(1)
4
.06V
J105
3
C119
.001
R110
100
28
L(1)
2
.06V
J105
8
C118
.001
R111
100
29
L(1)
5
.06V
J105
2
C117
.001
R112
100
30
L(1)
1
.04V
J105
7
C116
.001
R113
100
31
L(1)
12
.02V
J105
4
C115
.001
R114
100
32
L(1)
13
.05V
J105
1
C114
.001
R115
100
33
L(1)
14
.05V
J105
6
C113
.001
R116
100
34
L(1)
15
.01V
16
1
5.08V (A)
CD4051BEXV
Z102
DECODER
2.54V
11
20
2.54V
10
19
2.54V
9
18
8
3
7
6
1
17
31
1
5.08V (A)
5V
1ms
0V
J105
13
C111
.001
R101
100
35
H(1)
4
4.85V
J105
11
C110
.001
R102
100
36
H(1)
2
4.85V
J105
14
C109
.001
R103
100
37
H(1)
5
4.85V
J105
10
C108
.001
R104
100
38
H(1)
1
4.85V
J105
17
C107
.001
R105
100
39
H(1)
12
4.85V
J105
12
C106
.001
R106
100
40
H(1)
13
4.85V
J105
15
C105
.001
R107
100
41
H(1)
14
4.85V
J105
16
C104
.001
R108
100
42
H(1)
15
4.85V
16
1
5.08V (A)
CD4051BEXV
Z101
DECODER
2.52V
11
23
2.52V
10
22
2.54V
9
21
5.02V
H(1) (12)
3
25
WAVEFORM TAKEN
WHILE PRESSING
THE RETURN KEY
6
7
8
R125
47K
1
5.08V (A)
5V
2ms
0V
4.8V
5ms
0V

Courtesy Howard W. Sams & Co., Inc.

GENERIC TROUBLESHOOTING
UNIT VI

ASSIGNMENT SHEET #1 — READ AND INTERPRET PARTS OF A COMPUTERFACTS™ SCHEMATIC

Directions: On the accompanying pages are selected items from a Howard W. Sams Computerfacts™. Reference the pages as needed to answer the following questions:

A. What should be completed before any troubleshooting is started?

Answer ______________________________

B. What should be the first preliminary service check?

Answer ______________________________

____

C. What is the final activity recommended prior to starting troubleshooting?

Answer ______________________________

____

D. What should be done at power up to prepare the microcomputer to program in BASIC?

Answer ______________________________

____

E. When making a power supply check at connector P204, what AC voltage should be expected?

Answer ______________________________

F. What kind of reading should be expected at the anode of Zener diode CR201?

Answer ______________________________

G. What voltage reading would be expected at the bridge rectifier diodes?

Answer ______________________________

H. What is the highest voltage reading you'd expect to find on the power supply and where should it be found?

Answer ______________________________

____

ASSIGNMENT SHEET #1

I. What is the meaning of S210 at 1B, and what is its function?

Answer ______________________________

____

J. At what gridtrace location is S201 found?

Answer ______________________________

K. At what points on the schematic would you expect to find readings of 12.23V?

Answer ______________________________

L. At what points on the schematic would you expect to find readings of 5.06V?

Answer ______________________________

M. How is the power switch indicated, what three locations are nearest it on the schematic, and should it be switched up or down to be on?

Answer ______________________________

____

N. What is the frequency of the X101 crystal?

Answer ______________________________

ASSIGNMENT SHEET #1

PRELIMINARY SERVICE CHECKS

This data provides the user with a time-saving service tool which is designed for quick isolation and repair of computer malfunctions.

Check all interconnecting cables for good connection and correct hook-up before making service checks.

Disconnect all peripherals except the monitor from the computer to eliminate possible external malfunctions.

Replacement or repair of the Power Board, RF Modulator, Keyboard, CPU Board, 16K RAM Board, Main Board or connectors may be necessary after the malfunction has been isolated.

GENERAL OPERATING INSTRUCTIONS

POWER UP

With a Basic cartridge plugged in, the computer will come up ready to program in Basic when turned On. See "Cassette Operation" for instructions on loading and saving programs on a cassette recorder.

To run a program, type RUN and press the RETURN key.

To stop a program, press the BREAK key or press the SYSTEM RESET key.

CASSETTE OPERATION

Connect the ATARI Program Recorder to the connector on the right side of the computer. NOTE: a regular cassette tape recorder will not function with the ATARI 400.

To load a program, type CLOAD and press the RETURN key. The speaker will beep once. After the speaker beeps, press the PLAY button on the recorder and press the RETURN key again. The program will then be loaded.

To save a program, type CSAVE and press the RETURN key. The speaker will beep twice. After the speaker beeps, press the PLAY and RECORD buttons on the recorder and press the RETURN key. The program will then be saved.

©Howard W. Sams & Co., Inc.; reprinted with permission

ASSIGNMENT SHEET #1

SERVICE CHECKS

SEE INTERCONNECTING DIAGRAM, PLACEMENT CHART, AND PHOTOS TO MATCH THE NUMBER IN THE CIRCLES WITH THOSE IN THE FOLLOWING DATA FOR SERVICE CHECKS TO BE PERFORMED.

① RF MODULATOR CHECK

(A) Apply power to computer and set Power Switch (S203) to On. Verify the Power Indicator LED (CR210) is lit. NOTE: If LED CR210 is not lit, refer to the "Power Supply Check" section.

(B) Verify the Channel Select Switch (S201) is on the same channel as the monitor, channel 2 or 3.

(C) Verify the TV/Computer Switch (In Switch Box) is in the computer position.

(D) Check for bad connections and improper hook-up at the monitor and at the computer.

(E) If the computer still does not come up with power applied, check the voltages at the RF Modulator connection points. If the voltages are correct, substitute the RF Modulator.

② POWER SUPPLY CHECK

(A) Connect Power Pack to 120V AC. Disconnect connector P204 from computer. Check for 10.42V AC at connector P204. If the voltage is not correct, substitute the Power Pack.

(B) Check for 11.84V at Bridge Rectifier Diodes (CR206 and CR208).

(C) Check for 5.08V at pin 3 of Voltage Regulator IC (A202).

(D) Check for 23.7V at pin 1 of Voltage Regulator IC (A201).

(E) Check for 12.25V at pin 3 of IC A201.

(F) Check for − 5.01V at the anode of Zener Diode CR201.

If any of the voltages are missing (B) thru (F) substitute the Power Board.

③ MAIN BOARD

(A) Power supply checks out properly, but the computer does not come up with power applied. Verify the 3.579575MHz Crystal (X101) is oscillating at the proper frequency.

(B) Crystal X101 oscillation is correct, but the computer still does not come up. Check the CPU Board and the 16K RAM Board by substitution.

(C) If the computer still does not come up, check ROM IC's (A103 and A104), Video Buffer IC (A111), and Decoder IC's (Z103 and Z104) by substitution.

(D) Computer comes up properly, but the cartridge does not work. Check ROM IC (A105) by substitution.

(E) Joysticks or paddles do not function. Check PIA IC (A102) by substitution.

(F) Computer comes up improperly with power applied. Check Decoder (Z105) by substitution.

(G) No color, no vertical or horizontal sync, or no audio. Check the CPU Board by substitution.

(H) Computer will not load or save a program to or from cassette. Check POKEY IC (A101) by substitution.

④ KEYBOARD

(A) A key does not function. Substitute the keyboard.

(B) Several keys do not function properly. Check the Keyboard Connector (J105) and check POKEY IC (A101) and Decoder IC's (Z101 and Z102 by substitution.

©Howard W. Sams & Co., Inc.; reprinted with permission

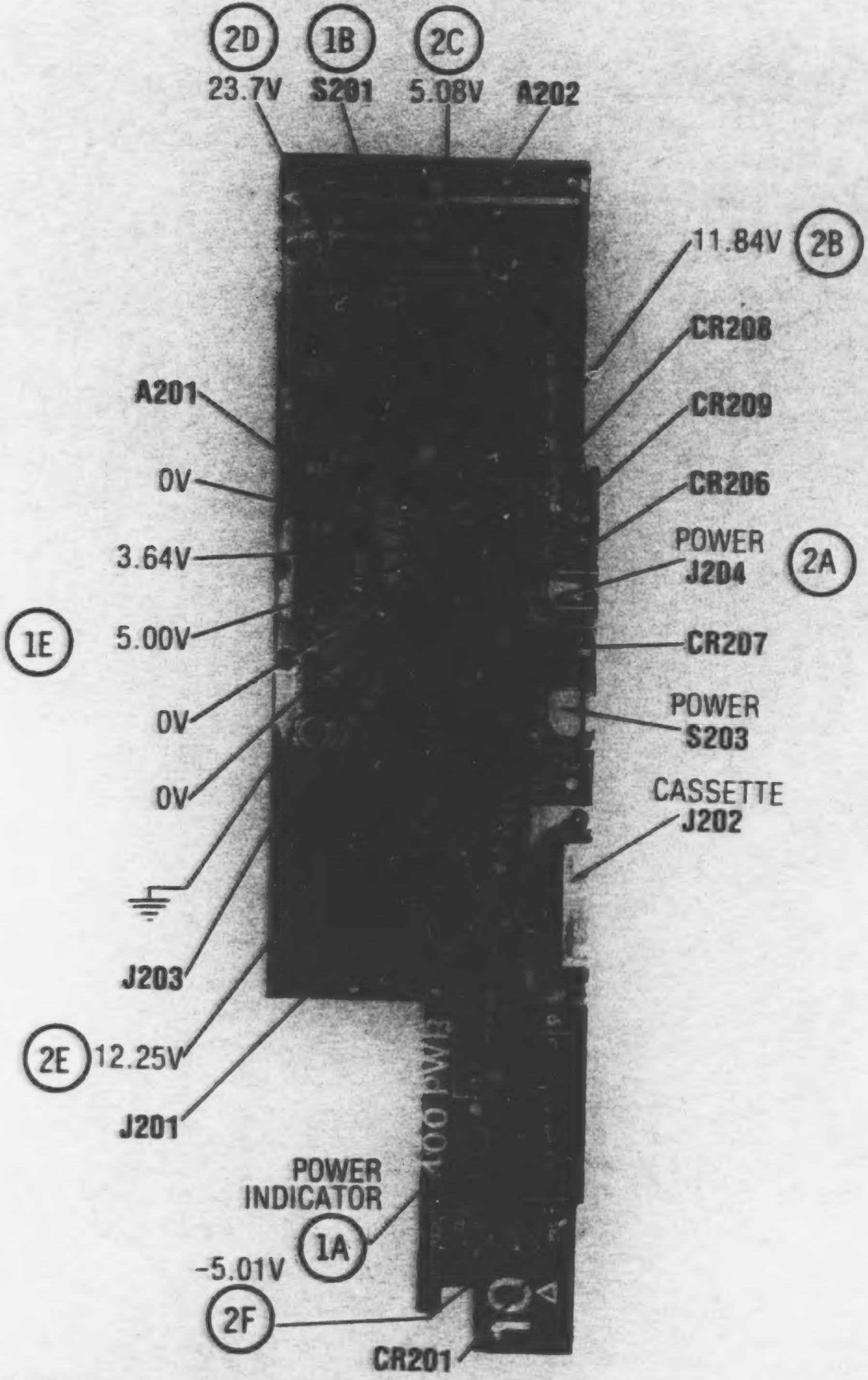
ASSIGNMENT SHEET #1

POWER BOARD GridTrace LOCATION GUIDE

A201	E-1	C207	H-3	CR202	N-4	CR210	M-3	L204	E-4
A202	A-3	C208	A-4	CR203	N-4	J201	K-2	L205	F-1
C201	K-3	C209	G-2	CR204	C-1	J202	J-4	R201	N-3
C202	M-4	C210	N-3	CR205	C-3	J203	H-1	R202	H-2
C203	D-1	C211	G-4	CR206	F-3	J204	F-4	R203	F-2
C204	I-1	C212	B-2	CR207	G-4	L201	G-3	S201	A-1
C205	D-4	C213	B-1	CR208	F-3	L202	H-4	S202	F-4
C206	I-3	CR201	N-4	CR209	G-3	L203	G-3	S203	H-4

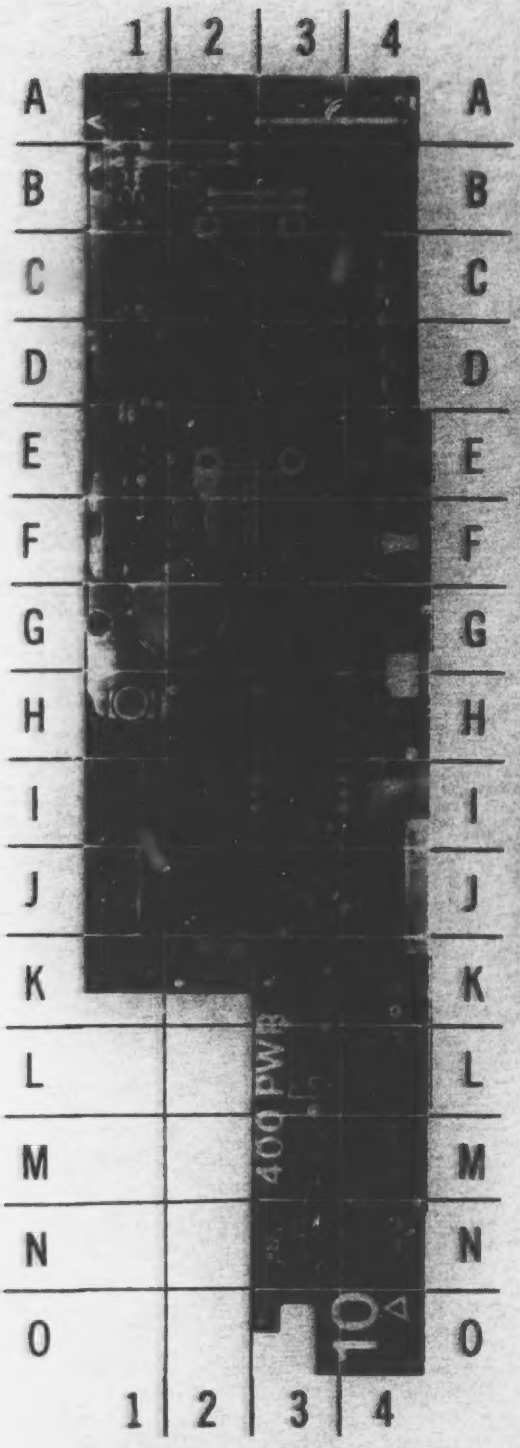
© Howard W. Sams & Co., Inc.; reprinted with permission

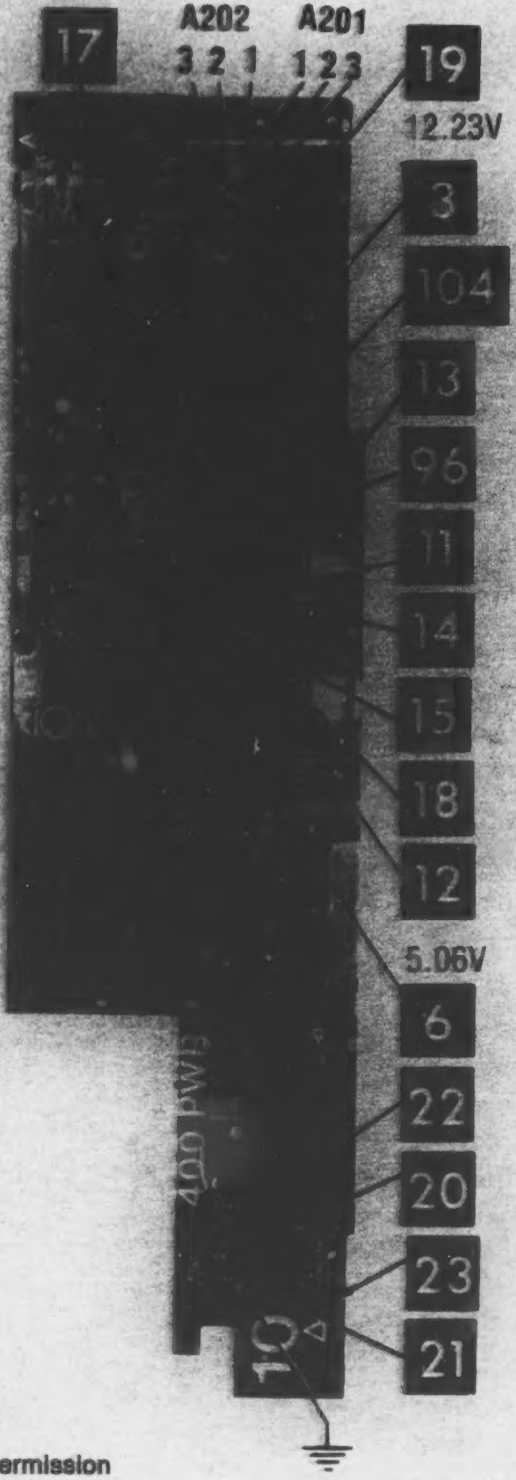
ASSIGNMENT SHEET #1


2D
23.7V
1B
S201
2C
5.08V
A202
11.84V
2B
CR208
CR209
CR206
POWER
J204
2A
CR207
POWER
S203
CASSETTE
J202
A201
0V
3.64V
1E
5.00V
0V
0V
J203
2E
12.25V
J201
400 PWB
POWER
INDICATOR
1A
-5.01V
2F
CR201

©Howard W. Sams & Co., Inc.; reprinted with permission

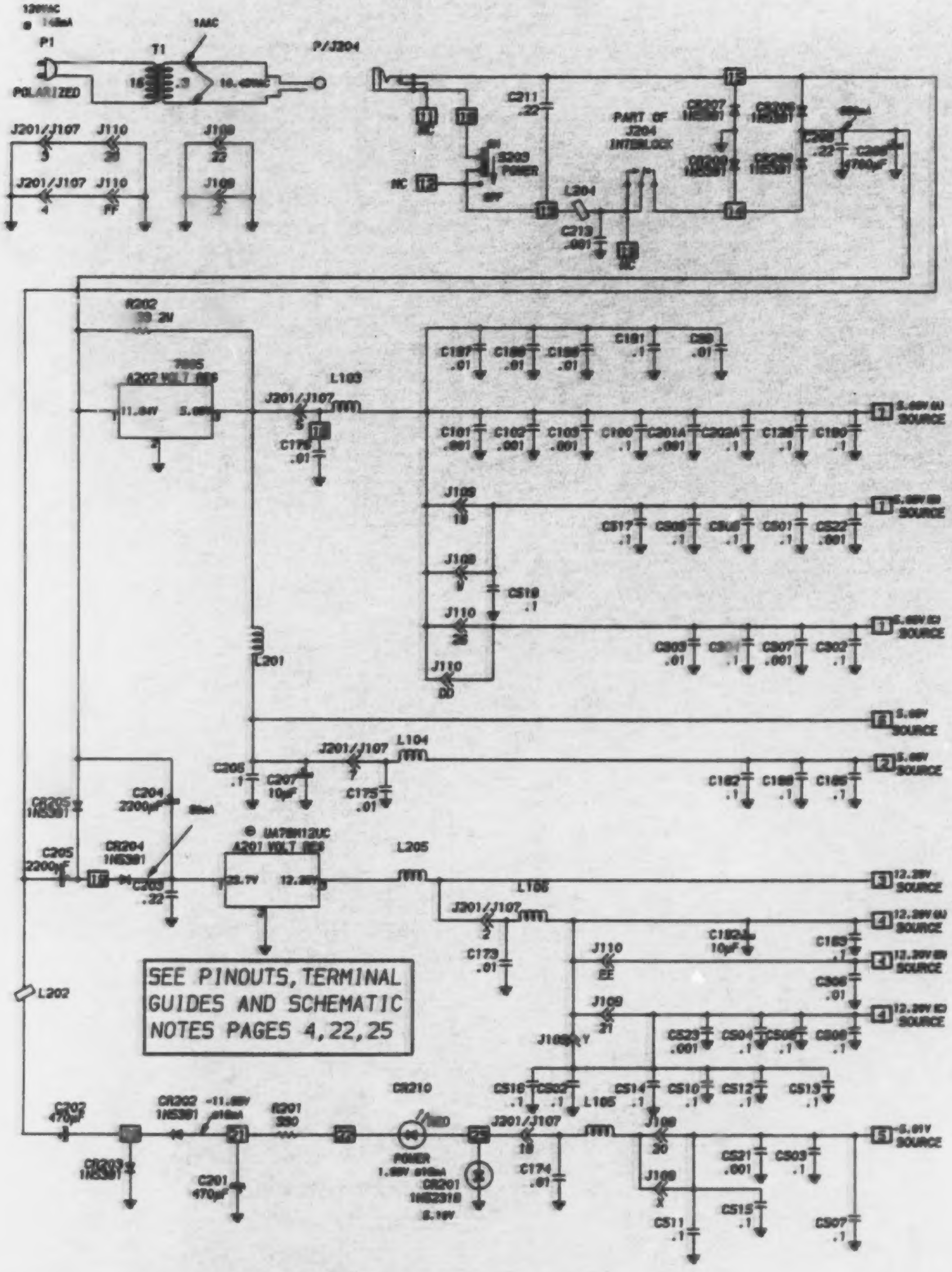
ASSIGNMENT SHEET #1


1
2
3
4
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
400 PWB
10


17
A202
3 2 1
A201
1 2 3
19
12.23V
3
104
13
96
11
14
15
18
12
5.06V
6
22
20
23
21
400 PWB
10

©Howard W. Sams & Co., Inc.; reprinted with permission

ASSIGNMENT SHEET #1


P1
POLARIZED
T1
P/J204
C211
.22
PART OF
J204
INTERLOCK
S203
POWER
OFF
NC
L204
C213
.001
J201/J107
J110
J109
R202
A202 VOLT REG
7805
11.04V
5.00V
L103
C176
.01
L201
5.00V SOURCE
C205
2200µF
CR205
1N5301
C204
2200µF
CR204
1N5301
C203
.22
UA78M12UC
A201 VOLT REG
22.7V
12.20V
L205
L106
12.20V SOURCE
L104
C206
.1
C207
10µF
C175
.01
C173
.01
L202
SEE PINOUTS, TERMINAL
GUIDES AND SCHEMATIC
NOTES PAGES 4,22,25
C202
470µF
CR202
1N5301
CR203
1N5301
R201
330
CR210
RED
POWER
C201
470µF
CR201
1N5231B
C174
.01
L105
-5.01V SOURCE

©Howard W. Sams & Co., Inc.; reprinted with permission

GENERIC TROUBLESHOOTING
UNIT VI

ANSWERS TO ASSIGNMENT SHEETS

A. Preliminary service checks

B. Check all cables for good connection and correct hook-up

C. Disconnect all peripherals except the monitor

D. Plug in a BASIC cartridge

E. 10.42V

F. -5.01V

G. 11.84V

H. 23.7V at pin #1 of the A201 voltage regulator

I. S210 is a channel select switch and it functions to place the channel on the same channel as the monitor

J. A-1

K. 3, 104, 13, 96, 11, 14, 15, 18, and 12

L. 6, 22, 20, 23, and 21

M. It is indicated as S203, it is near locations 18, 12, and 13 on the schematic, and it should be switched up to be on

N. 3.579575MHz

GENERIC TROUBLESHOOTING
UNIT VI

JOB SHEET #1 — CUT AND DESOLDER PINS AND REMOVE A CHIP FROM A PRINTED CIRCUIT BOARD

A. Tools and equipment

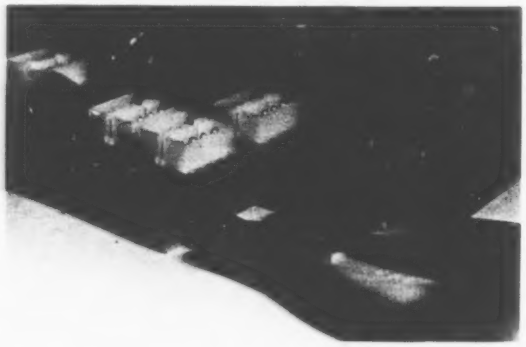
1. Printed circuit board with soldered chip(s)
2. Soldering iron
3. Desoldering wick or bulb
4. Diagonal cutting pliers
5. Safety glasses

B. Procedure

1. Plug soldering iron in and allow it to warm up
2. Secure printed circuit board in a clean work area
3. Use the diagonal cutting pliers to cut all pins at about midpoint so enough of each pin is left protruding from the PC board that it can be grasped with a pair of pliers (Figure 1)

   (NOTE: Do not cut pins flush with the board.)

   FIGURE 1



4. Put the desoldering wick in place or have a solder pickup instrument ready for use

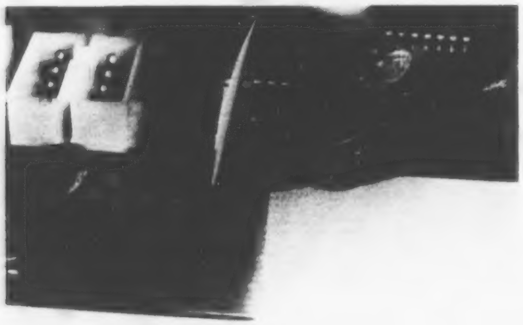
JOB SHEET #1

5. Plan a staggered technique for removing the pins

   (NOTE: This means to start with the pin at the lower right corner, and generally to move the soldering iron in a random pattern up and down and from side to side to avoid overheating the PC board.)

6. Apply the soldering iron to the soldered connection that holds a pin to the board and lift the pin out with a pair of pliers as the solder melts (Figure 2)

   FIGURE 2



7. Repeat the procedure for each of the pins of the chip, and be sure to stagger the pattern to better distribute the heat from the soldering iron

8. Set the soldering iron aside when completed and unplug it

9. Allow the board to cool

10. Check the printed circuit board for a smooth, clean surface along the lines where the pins were removed

    ☐ Have your instructor check your work

11. Clean up area and return tools and equipment to proper storage

    (NOTE: This procedure is a handy one for replacing IC's soldered to a board, and it's a general recommendation that soldered IC's be replaced with sockets so future repairs will not necessitate desoldering again; this is a situation presented with chip replacement on the Commodore 64 and in other applications.)

GENERIC TROUBLESHOOTING
UNIT VI

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Software designed to check system functions

_____b. Troubleshooting routines that apply generally to almost all microcomputers

_____c. A new component made by a reputable manufacturer or a working component taken from a system that is operating properly

_____d. The logical arrangement of troubleshooting routines so that elements common to overall operation are checked first so that other problems can be isolated with speed and accuracy

_____e. The mass replacement of ROM, RAM, or other components in the hopes of quickly correcting a malfunction without having to troubleshoot a system

_____f. A period after repairs are completed when a system is operated for an extended time in order to prove replacement components and total system functions

1. Known good component
2. Shotgunning
3. Diagnostics
4. Systematic troubleshooting
5. Generic troubleshooting
6. Burn-in time

2. Select true statements concerning first rules for advanced troubleshooting by placing an "X" in the appropriate blanks.

_____a. Always run diagnostic software when it is available and when a microcomputer or disk drive is operational to the point that it will run the diagnostics

_____b. Use data or logic analyzers whenever they are available because they provide accurate information and permit troubleshooting at critical points in a microcomputer system

_____c. When a system is inoperative or experiencing an intermittent problem, take time to make intelligent guesses, then start where you think the problem is

TEST

3. Complete the following list of troubleshooting preliminaries by inserting the word(s) that best completes each statement.

   a. Make sure the proper ____________ accompanies the equipment

   b. Evaluate written descriptions of the problem according to the ____________ of the submitting party

   c. Make sure the equipment suffered no ____________ damage

   d. Once the cover or case is removed from a piece of equipment, make a quick ____________ check for burned or broken parts and loose cables and connectors

   e. Attempt to ____________ the problem described by the submitting party

4. Complete the following statements concerning the rationale and order of systematic troubleshooting by inserting the word(s) that best completes each statement.

   a. The ____________ ____________ should always be checked ____________ because it is the source of operating voltages for the entire system and must be functional before other components can be checked

   b. The ____________ system controls many operational activities and should be checked ____________

      1) Supply voltages to the ____________ must be correct or there can be no control functions

      2) The system ____________ must be working properly or addressing and data transfer cannot take place

      3) ____________ and control signals must be at the proper logic level or the microprocessor functions will stop

      4) There must be activity on the ____________ and ____________ ____________ for the transport and exchange of control information

   c. Because it also serves control functions, system ____________ should be checked ____________

   d. Because it is the storehouse of information the systems works with, system ____________ should be checked ____________

   e. Because they connect the microcomputer with the outside world, ____________ functions should be checked ____________

TEST

5. Select true statements concerning other elements of systematic troubleshooting by placing an "X" in the appropriate blanks.

_____a. Check and reseat IC's as required, and remember that sometimes perplexing problems have been traced to bad connectors, loose or faulty sockets, and similar mechanical problems

_____b. Develop a knack for backtracing with a current tracer because once proper voltages are verified at the power supply, backtracing is an effective technique for isolating line breaks

_____c. Pay attention to the circuitry associated with specific components because problems with single transistors, resistors, and capacitors can cause major malfunctions or contribute to perplexing intermittents

_____d. Substitute known good components for verified or suspected faulty components as early as possible because that is the way to save time

_____e. Pay constant attention to improving your soldering and desoldering skills for there will be times when these skills are needed to solve a problem

6. Complete the following list of habits that promote better troubleshooting by inserting the word(s) that best completes each statement.

a. Take time to reevaluate your troubleshooting at ____________ points in the routine and do not continue until you know that you have executed a given routine properly

b. Take notes when you solve unusual or difficult problems and if there are no files where you work, start your own equipment "____________" files and add to them from personal experience

c. Make a habit of using ____________ and ____________ because they can save you a great deal of time

d. Be alert for problems in graphic materials you use, and when you find a problem in a schematic or diagram, ____________ ____________ so you won't run into the same problem again

e. Post technical ____________ where they can be clearly seen and referenced the next time a piece of equipment with a similar problem comes in for repair

TEST

7. Complete the following statements concerning graphic materials and their uses in troubleshooting by inserting the word(s) that best completes each statement.

   a. As with ____________ in the building trades, graphic materials which provide representative pictorial guidance are essential for efficient microcomputer troubleshooting

   b. Graphic materials range in sophistication from simple block diagrams to intricate system schematics, and referencing the proper graphic material is not only time saving, it is frequently ____________

8. Select true statements concerning block diagrams and their characteristics by placing an "X" in the appropriate blanks.

   (NOTE: For a statement to be true, all parts of the statement must be true.)

   _____a. Block diagrams are used to show relationships between large groups of circuitry or entire microcomputer subsystems

   _____b. Block diagrams are so called because the shapes used to depict components in a system are rectangular spaces labeled to indicate component names

   _____c. The representative components in a block diagram are usually connected by lines to indicate the direction of signal flow:

      1) Wide single lines usually represent busses

      2) Double lines usually represent control signals or power connections

   _____d. A single arrow on a block diagram usually traces the origin and destination of a signal and an arrow on each end of a line indicates bidirectional information flow such as with data or I/O busses

9. Complete the following statements concerning schematics and their characteristics by inserting the word(s) that best completes each statement.

   a. Anyone planning to work at advanced level troubleshooting with microcomputers must have schematics available and ____________ ____________ ____________ ____________ ____________

   b. Schematics for microcomputers are designed for troubleshooting and will almost always include:

      1) ____________ numbers

      2) ____________ numbers

      3) ____________ and current requirements

      4) ____________ pictorially presented so they can be compared with test waveforms screened on an oscilloscope

      5) Standard electronic ____________ for resistors, capacitors, transistors, IC's, and other components

TEST

c. Although some component troubleshooting can be done without a schematic, troubleshooting a complete system without a schematic would be an adventure in ____________ ____________

d. Using a schematic properly will reduce troubleshooting time and keep repair costs down by eliminating the expensive practice of ____________

10. Select true statements concerning other graphic aids for troubleshooting by placing an "X" in the appropriate blanks.

_____a. PC board diagrams are useful troubleshooting aids especially when they have overlaid numbering showing where test points are located or where certain components are located on the back side of the board

_____b. PC board diagrams are sometimes needed to help identify circuits used on the PC board

_____c. Some helpful manufacturers have identification information silk-screened onto their boards, but without this, a troubleshooter needs the help of a diagram

_____d. Line diagrams of specific components are not especially useful but they help when other materials are not available

_____e. Line diagrams are also used for pinouts and to depict waveforms generated by clock and timing signals

_____f. Bubble diagrams are useful for graphically presenting complex troubleshooting routines which branch out from a starting place into subroutines then back to a main routine

11. Complete the following statements concerning schematics and troubleshooting guides by inserting the word(s) that best completes each statement.

a. Another excellent source of schematics and ____________ guidelines is Computerfacts™

b. Computerfacts are available for most of the popular brands of ____________, ____________ ____________, ____________, and ____________ ____________ ____________

c. Major components in a typical Computerfacts include:

1) A list of ____________ service checks

2) ____________ including standard notations for waveforms, voltages, and stage identification

3) Step by step ____________ guides

TEST

4) A component by component ____________ list

5) Excellent ____________ with map-type grid references to help locate components quickly

6) A ____________ chart to assist in finding faulty circuitry with a logic probe

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Read and interpret parts of a Computerfacts™ schematic. (Assignment Sheet #1)

13. Demonstrate the ability to cut and desolder pins and remove a chip from a printed circuit board. (Job Sheet #1)

GENERIC TROUBLESHOOTING
UNIT VI

ANSWERS TO TEST

1. a. 3
   b. 5
   c. 1
   d. 4
   e. 2
   f. 6

2. a,b

3. a. Paperwork
   b. Reliability
   c. Shipping
   d. Sensory
   e. Duplicate

4. a. Power supply, first
   b. Kernel, second
      1) Microprocessor
      2) Clock
      3) Interrupts
      4) Address, data busses
   c. ROM, third
   d. RAM, fourth
   e. I/O, fifth

5. a,b,c,e

6. a. Logical
   b. History
   c. Diagrams, schematics
   d. Correct it
   e. Updates

7. a. Blueprints
   b. Mandatory

8. a,b,d

9. a. Know how to use them
   b. 1) Part
      2) Pin
      3) Voltage
      4) Waveforms
      5) Symbols
   c. Wasted time
   d. Shotgunning

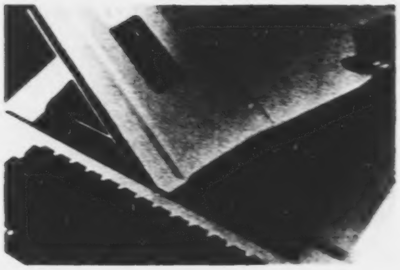
ANSWERS TO TEST

10. a,b,c,e,f

11. a. Troubleshooting
    b. Microcomputers, disk drives, printers, video display units
    c. 1) Preliminary
       2) Schematics
       3) Troubleshooting
       4) Parts
       5) Photographs
       6) Logic

12. Evaluated to the satisfaction of the instructor

13. Performance competencies evaluated according to procedures outlined in the job sheet



TROUBLESHOOTING THE APPLE II®
MICROCOMPUTER
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to solve problems concerning systematic troubleshooting of the main board on an Apple II or Apple II Plus microcomputer. The student should also be able to prepare an Apple microcomputer for main board troubleshooting, troubleshoot the power supply, and troubleshoot a main board. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to troubleshooting the Apple II® microcomputer with their correct definitions.
2. Solve problems concerning troubleshooting the power supply.
3. Complete statements concerning other power supply checks.
4. Solve problems concerning troubleshooting the clock.
5. Complete statements concerning repairing a faulty clock.
6. Solve problems concerning troubleshooting control lines.
7. Arrange in order the steps in determining when to substitute a microprocessor.
8. Solve problems concerning troubleshooting ROM.
9. Solve problems concerning troubleshooting RAM.
10. Complete statements concerning troubleshooting I/O functions.
11. Complete statements concerning characteristics of the keyboard and interface components.

OBJECTIVE SHEET

12. Solve problems concerning troubleshooting the keyboard and components.
13. Complete statements concerning time-saving routines for troubleshooting a keyboard.
14. Solve problems concerning troubleshooting video I/O.
15. Complete statements concerning troubleshooting video components.
16. Complete statements concerning troubleshooting video color problems.
17. Solve problems concerning troubleshooting audio problems.
18. Solve problems concerning troubleshooting cassette tape I/O.
19. Demonstrate the ability to:
    a. Prepare an Apple microcomputer for troubleshooting. (Job Sheet #1)
    b. Troubleshoot the power supply on an Apple microcomputer. (Job Sheet #2)
    c. Troubleshoot the main board on an Apple microcomputer. (Job Sheet #3)

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss unit and specific objectives.

D. Discuss information sheet.

E. Invite an Apple dealer who has a good repair service to talk to the class about problems peculiar to the Apple systems.

F. Supplement schematic materials with Computerfacts C5 if sufficient schematic information is not available from the OEM.

G. Review the job sheets in this unit of instruction and note the places where chip numbers or component nomenclature may vary from that of the OEM numbers or nomenclature, and alert students about the variations.

H. Study Computerfacts C5 or OEM data for places where the main board may be safely disabled so that students will have realistic problems to detect as they complete the troubleshooting routines outlined in the job sheets.

I. Demonstrate how to write a program in BASIC to "loop" the system for troubleshooting audio problems where a constant signal is required for monitoring.

J. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

    1. Job Sheet #1 — Prepare an Apple Microcomputer for Troubleshooting

    2. Job Sheet #2 — Troubleshoot the Power Supply on an Apple Microcomputer

    3. Job Sheet #3 — Troubleshoot the Main Board on an Apple Microcomputer

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Apple II DOS User's Manual.* Cupertino, CA 95014: Apple Computer Inc., 1984.

B. *Apple II 80-Column Text Card Manual.* Cupertino, CA 95014: Apple Computer Inc., 1984.

C. *Computerfacts™ CC1.* Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1985.

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

INFORMATION SHEET

I. **Terms and definitions**

   A. Decoder — An electronic device that converts a binary or other coded number into a decimal number

   B. Encoder — An electronic device that converts a decimal number into a binary or other coded number

   C. OEM — Original equipment manufacturer

   D. PC — Printed circuit

   E. Random — By chance or in no specific order

   F. TTL — Transistor, transistor logic

   G. VDU — Video display unit

II. **Troubleshooting the power supply**

   A. Look for loose connections around the power supply and try to detect any smells that would indicate burned components

   B. All power supply voltages available from the power supply should be checked:

      1. Voltages may be listed as +12V and -12V and +5V and -5V

      2. Voltages will actually be +11.7V and -11.8V and +4.97V and -5.1V

   C. Check and validate all power supply voltages and record your findings in a troubleshooting log

   D. Check resistors and other components as necessary and replace faulty components

   (NOTE: See Job Sheet #2 for step-by-step instructions.)

III. **Other power supply checks**

   A. Validate all power supply voltages; then make random voltage checks at other points in the system

   B. Check power voltages at the CPU in random locations

   C. Check power voltages at random memory locations

   D. The presence of proper voltages is an indication that the power supply distribution bus is okay and the trouble is somewhere else

INFORMATION SHEET

IV. **Troubleshooting the clock**

A. Refer to the appropriate pinout diagram and locate pin numbers where key checks should be made

B. The presence of the clock signal outputs on pins labeled ϕ1 and ϕ2 should produce a pattern of rectangular nonoverlapping waveforms

C. If the proper waveforms are not present, check the input to the microprocessor at ϕ0 (pin 37) for the proper input waveform

D. Remember to check all waveforms for voltage, phase, and frequency

E. If the proper signal does not appear at ϕ0, then trace backwards from pin 37 through the frequency divider all the way to the crystal oscillator

(NOTE: At this point, a clever troubleshooter would probably use a half-splitting routine to quickly isolate the problem.)

F. Troubleshooting the clock may lead to finding:

1. A faulty divider chip
2. A faulty oscillator
3. A faulty crystal
4. A broken trace between components
5. A possible mechanical failure as simple as a worn socket or a bad connection

V. **Repairing a faulty clock**

A. Troubleshoot and isolate the problems as previously outlined

B. Replace any faulty component that can be replaced

C. Resolder joints as required

D. Replace socket if required

E. Complete repairs and check again at the microprocessor for proper waveforms at ϕ0, ϕ1, and ϕ2

F. If the check validates proper signals at the microprocessor, test the system to see if it works

(NOTE: Remember that good troubleshooting means finding and correcting the problem as quickly as possible, so correcting a clock problem could easily solve the entire system problem, and the system check should be made at this point.)

INFORMATION SHEET

VI. Troubleshooting control lines

A. If the computer still fails to perform any operation after the power supply and clock system have been validated, then the four control lines that can prevent the system from operating should be checked:

1. The $\overline{\text{NMI}}$ at pin 6
2. The $\overline{\text{IRQ}}$ at pin 4
3. The $\overline{\text{RES}}$ at pin 40
4. The $\overline{\text{RDY}}$ at pin 2

B. If any one of the three interrupt control lines ($\overline{\text{NMI}}$, $\overline{\text{IRQ}}$, and $\overline{\text{RES}}$) is at a low logic level, it can prevent the entire system from operating

C. If the $\overline{\text{RDY}}$ or memory read line is at low logic level, it can put the microprocessor on hold and prevent the entire system from operating

D. The three interrupt lines derive inputs from various parts of the system, but one of the problems common to inputs concerns the $\overline{\text{RES}}$ line:

1. The circuitry that carries information to the RESet line contains an IC timer or an RC network
2. If the circuitry is faulty, the timer or the RC network should be checked

E. The $\overline{\text{NMI}}$ and $\overline{\text{IRQ}}$ lines are connected to a number of features and the troubleshooter must trace these lines while referencing a good schematic

F. Any control lines that are at low logic level, below .8V, indicate a problem which must be found so that the line(s) can be restored to high logic level or approximately 3.5V

G. Replace components as required to correct the problem

VII. Steps in determining when to substitute a microprocessor

A. Check power supply voltages and correct as necessary

B. Check clock and timing and correct as necessary

C. Check control lines and correct as necessary

D. Attempt to operate the system

E. If the system does not operate at this point, it is time to temporarily replace the microprocessor with a known good microprocessor to assure that the problem is not in the microprocessor chip

F. If the system does not operate after substitution of a known good microprocessor, then system memories should be checked starting with ROM

INFORMATION SHEET

VIII. Troubleshooting ROM

A. The quickest way to troubleshoot ROM is to have a known good operating system ROM and substitute it for the suspected faulty ROM

(NOTE: Replace ROM F8 first, then if the system will not boot up, replace other ROM's in order.)

B. If a known good ROM is not available, but a second system is available, swap ROM's to see if the trouble moves to the second system

C. Once the faulty ROM is identified, replace it with a known good ROM and check the system out to see if it will operate properly

(NOTE: When a system can be exercised by some external device, it is possible to write a short machine language program that will sum all of the binary characters stored in the operating system ROM, and this "sum check" as it is called should agree with the sum check in the User's Guide; in fact, most new computer systems do a self-check on starting up and that check is pretty much a sum check.)

D. Once the operating system ROM is validated, the next logical troubleshooting step is to check RAM

IX. Troubleshooting RAM

A. Boot the system up and run the diagnostic disk or plug-in card to make a RAM check

B. If the diagnostics will not run, replace the first bank of RAM, then repeat for each RAM bank until problem is located

C. Once RAM has been validated, and the system will still not operate, move back to the decoding system that decodes the memory lines

(NOTE: This logic is usually one of a series of TTL parts that are specifically designed to decode signals from the microprocessor, produce an appropriate decoded signal for the memory addressing lines and for the select lines used to access specific memory blocks.)

D. An oscilloscope is required to identify the signals appropriate to drive the memory address lines, and information in OEM data or from Computerfacts™ should be used to evaluate the signals

E. Once it is established that the decoder is failing to produce the proper output, replace the decoder

INFORMATION SHEET

F. If replacing the decoder fails to correct the problem, check the socket, PC traces, and any connections that could either ground or open up the address or memory select lines

G. As soon as the faulty chip has been replaced or the PC line or socket repaired, run the diagnostics again

H. If the appropriate checks have been made with the power supply, the microprocessor, the clock, ROM, RAM, and decoder for memory lines, and the system still will not operate, then the next logical place to troubleshoot would be the I/O functions

X. **Troubleshooting I/O functions**

A. When a peripheral device is working, especially the keyboard, it is possible to evaluate I/O functions by encoding a test program

B. In order to write a short test program, the troubleshooter must know the memory locations for the various parts of the system and the machine codes for the microprocessor

C. If a test program cannot be written or run, other I/O checks for the Apple can be checked in other ways, and these include only two significant I/O devices:

1. The keyboard
2. The video terminal

XI. **Characteristics of the keyboard and interface components**

A. The keyboard and its interfacing components for this computer include:

1. A universal peripheral interface 8-bit microprocessor, usually an Intel 8041, but sometimes from a second source
2. Timer and clock
3. ROM
4. RAM
5. I/O
6. One 8-bit status register
7. Two 8-bit data registers for asynchronous activity

B. The 8041 encodes the information from the keys to the 6502 microprocessor so the 6502 is freed of that function and can work faster

INFORMATION SHEET

C. Along with the keyboard encoder, there are buffers that buffer the signals from the encoder into a multiplexer, and that information is then sent to a transceiver which in turn sends it to the microprocessor data lines

D. Since the data bus must be used for things other than reading the keyboard, the transceiver sends information to and from the microprocessor data line and to all other parts of the system that need to exchange data with the microprocessor

(NOTE: In other words, the transceiver is acting much like a telephone switching system where many lines are connected to one telephone, and in this case, the keyboard is only a part of what the transceiver services, and in that respect, the transceiver is part of the I/O structure of the system.)

E. Between the keyboard and the microprocessor are four basic parts:

1. Transceiver

2. Three-state multiplexers which control the timing of various parts sending information into the transceiver

3. Buffer which increases the signal/strength out of the 8041

4. The 8041 which receives input directly from the keyboard, encodes it, and sends it on to the microprocessor

XII. **Troubleshooting the keyboard and components**

A. The simplest troubleshooting routine for the keyboard is to substitute a known good keyboard and encoder for the faulty ones

(NOTE: The keyboard and encoder are usually tied together with a jack and plug arrangement, and using this routine serves to "half-split" the trouble because the keyboard and its encoder represent about half of the number of components between the keyboard and the 6502.)

B. If substituting the keyboard and encoder solves the problem, then troubleshoot the original keyboard and its encoder

C. Substitute the 8041 encoder chip with a known good chip to half-split the rest of the problem

(NOTE: The 8041 is about halfway between the keyboard and the remaining components of the system.)

D. If substituting the 8041 encoder chip doesn't solve the problem, substitute the single chip in the data line, the buffer chip 74LS04

E. If substituting the 74LS04 buffer chip doesn't correct things, the problem is either in the keyboard itself or in some of the control circuitry

F. To see if the problem is in the control circuitry, substitute the two 74LS00 chips because all of the control logic is contained in these two chips

INFORMATION SHEET

G. If the new 74LS00 chips do not solve the problem, check the keyboard itself by looking at the electrical signals on an oscilloscope according to the intersections of the row/column matrix

(NOTE: Be sure to check OEM data or Computerfacts for the row/column matrix information.)

XIII. Time-saving routines for troubleshooting a keyboard

A. Signature analysis can be used effectively to troubleshoot a keyboard, but the different signatures for each key closure have to be available for reference

(NOTE: This usually means that the original signature analysis had to have been made with some sort of repeating program, and the information for that specific microcomputer is all that should be used for reference.)

B. When the system is operating to a point that disk information can be screened, the easiest troubleshooting routine is to use a keyboard diagnostic floppy disk for a key by key analysis of keyboard performance

(NOTE: In the absence of either of the alternatives listed above, troubleshooting will have to follow closely to the routine outlined in the following objectives.)

XIV. Troubleshooting video I/O

A. First, determine if the monitor is working by substituting a good monitor for the system monitor

B. When substitution of a good monitor still produces a totally blank screen or black screen it means that no video or timing information for creating the screen raster is being sent to the system and troubleshooting video components will be required

C. If the VDU is working, the next logical step would be to look at the composite video signals on an oscilloscope:

1. Check vertical video signal
2. Check horizontal video signal
3. Compare waveforms with OEM data or Computerfacts
4. Check voltages as required

INFORMATION SHEET

D. If the vertical and horizontal signals are present and voltages are correct, then look for something wrong between the microcomputer and the VDU:

1. Check for a faulty cable

2. Check for a faulty RF converter

3. Check for faulty connections

E. If the video signals are correct, and if the monitor will accept the composite video signal without the RF converter, the trouble is in the cable or the connectors and they should be checked and replaced as needed

F. If the composite video signal is present, but not correct, it requires troubleshooting the various video components by tracing back through the video section of the system

XV. **Troubleshooting video components**

A. Other than the video picture content, the remainder of the video signals are generated in the stages immediately preceding the composite video output

B. The best approach is to check the waveform output of each of the stages producing the various parts of the composite video signal

C. When an improper waveform is detected, keep tracing back in that same circuit until you find the place where the correct signal appears

D. When you find a normal signal going into a component, then check the output, and if the normal signal is missing at the output, replace that component

E. When tracing the circuit component by component does not reveal the source of the problem, then carefully examine the socket and circuit wiring

XVI. **Troubleshooting video color problems**

A. If there is a video signal but no color, the section identified as the color killer on the schematic should be checked

B. Loss of color in the video may also be caused by a failure in the color reference signal and the associated logic components or failure in a resistive part of that circuitry

C. Identify the color-related signals on the schematic and use an oscilloscope to check for proper waveforms

D. Finding and replacing the component that has proper signal input and an improper signal output will usually solve the problem if it reaches this far into the video section

E. Pay special attention to the schematic for pin numbers where luminescence and tint can be verified and check both carefully as well as the associated circuitry

INFORMATION SHEET

XVII. **Troubleshooting audio problems**

A. I/O associated with the audio signal is generated off address lines A4, A5, A6, and A7

B. When audio fails, the first logical step is to check all voltages around the audio circuit

C. If the audio signal is being sent, but not being heard, use the following procedure:

1. Write a basic language program to "beep" the system in a looped program so there will be a constant signal for monitoring
2. Monitor the signal with an oscilloscope and trace it back through the audio amplifier or the MPSA13 transistor known as the Darlington pair, then back through the flip-flop and finally back to the 74LS138 decoder
3. Replace faulty components as required, but audio problems in this part of the system are almost always found in the Darlington pair transistor

(NOTE: The audio failure of the Darlington pair means no audio at all because this transistor acts as an audio amplifier.)

XVIII. **Troubleshooting cassette tape I/O**

A. The heart of the cassette tape drive in this microcomputer is basically two major components:

1. An MC1741 op-amp which produces signals to be sent to the D7 data line via a multiplexer
2. The 74LS251 multiplexer which is used with some other features

B. Since a multiplexer failure would cause other problems, the component most likely to be faulty is the op-amp or its associated circuitry

C. Since the multiplexer also serves to produce the signal for sound to the signal, check the system with a beeper program to see if there is sound

D. If there is no sound and there is also a cassette tape problem, then the fault is probably in the 74LS251 multiplexer since it serves these two different parts of the system

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

JOB SHEET #1 — PREPARE AN APPLE MICROCOMPUTER FOR TROUBLESHOOTING

A. Tools and equipment

1. Apple II or Apple II Plus microcomputer
2. Standard and Phillips screwdriver
3. Oscilloscope
4. DVOM
5. Logic probe
6. OEM repair manual and schematic, if available
7. Computerfacts™ CC1, if required
8. Troubleshooting log and pencil

B. Procedure

1. Place microcomputer on the work bench so that there is sufficient free work space around it, and sign on your troubleshooting log

   (NOTE: Be sure to save your troubleshooting log for use with the other job sheets in this unit.)

2. Unplug the microcomputer and remove the power cord from the power supply
3. Snap the connector apart that holds the cover, remove the cover, and lay the cover far enough aside so that it will be out of the way
4. Check to see if the RF connector has been installed inside, and if it has, disconnect the plug-in connector
5. Remove the four Phillips screws at the back of the case opposite the keyboard
6. Turn the microcomputer over and remove only the outside Phillips screws (there should be 10 of them)
7. Lift the cover up slowly, look down and locate the four screws holding the keyboard onto the cover, and then remove the four screws

   (NOTE: The keyboard cable is short and it is best to disconnect it to get at the screws, then reconnect it.)

JOB SHEET #1

8. Remove the cover from the microcomputer to expose the main board, power supply, keyboard, and other components and be sure to set the keyboard aside so it does not rest on any PC board

9. Sign off your troubleshooting log

10. Have your instructor check your make-ready procedure to see if:

    a. Cover has been properly removed and set aside

    b. Screws removed have been saved for replacement

    c. Keyboard has been properly removed and set aside

    d. Main board, power supply, and other components are properly exposed for troubleshooting

11. Return tools and equipment to proper storage areas or prepare for next job sheet as directed by your instructor

JOB SHEET #1

Troubleshooting and Repair Log

Customer's Name ______________________________ Invoice ____________________

Date ____________________ Equipment and Serial # ______________________________

Complaint ____

____

Technician's Name & ID #	Date	Time On	Time Off	Work Performed	Replacement Parts Used & Inventory #

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

JOB SHEET #2 — TROUBLESHOOT THE POWER SUPPLY ON AN APPLE MICROCOMPUTER

A. Tools and equipment

1. Apple II or Apple II Plus microcomputer
2. Basic tool set
3. DVOM or VOM
4. Oscilloscope
5. Needle nose pliers, drill, and 5/32" bit (if required)
6. Troubleshooting log and pencil
7. Safety glasses as required
8. OEM schematic or Computerfacts™

B. Routine #1 — Checking power supply voltages

1. Make sure the AC power cord is unplugged at both ends, from the AC socket and from the power supply itself

   (NOTE: Be sure to sign on your troubleshooting log.)

2. Check to make sure that the power supply connector to the main board is still connected

   (NOTE: This is a switching type power supply and must be under load before it can be properly tested; in fact, if the connector to the main board is disconnected, all power supply output will be stopped to protect the power supply, and the lack of any voltage readings at the power supply output could lead a troubleshooter to mistake the power supply as faulty when it is actually in good working order.)

3. Select any one of the eight peripheral connectors at the back of the main board to use as a place to measure power supply voltages

4. Observe the arrows on the board because each arrow points toward the end where pin 1 will be found, pin 1 will be on the left side of the arrow, and the other pin numbers will follow counterclockwise around the chip

5. Set the DVOM to measure DC voltage in a range that will contain 12 volts

   (NOTE: With some meters, this may be a 20V range, some a 25V range, some 30V, and some 50V, but whatever meter is used, be sure it is set to contain the 12V range.)

JOB SHEET #2

6. Locate the ground at pin 26 and place the DVOM ground connection, usually the black one, on pin 26

   (**CAUTION:** Be very careful not to let the ground probe touch the adjacent DMA pin or it will cause a short, and remember throughout this routine to make sure the probe touches only the pin being tested.)

7. Take the remaining free probe, usually red, and place it on pin 25 as you make sure the ground probe is firmly touching pin 26

8. Check your DVOM for a reading of 4.97V

   (NOTE: Don't panic if you get no reading at all because you're dealing with a fused system and no voltage at all indicates a need to remove the power supply cover and examine the fuse, and that will be covered later in the routine.)

9. Keep the ground firmly touching pin 26, then move the free probe to pin 50 and check for a measurement of +12V, although it may actually be +11.7V

10. Check to see if the meter you are using will automatically set polarity, and if it will not, then take the red lead and place it on the ground at pin 26 and use the black lead to measure negative voltages

11. Measure for a reading of -5V (it will be slightly higher) at pin 34 and a reading of -12V (it will be slightly lower) at pin 33

12. Record all voltage readings in the troubleshooting log then prepare for troubleshooting the power supply circuitry

13. Have your instructor check your troubleshooting log for results of your power supply voltage checks, and if any voltages do not conform to recommended voltages, prepare for troubleshooting the power supply circuitry by disconnecting the power supply from the main board

C. Routine #2 — Checking power supply circuitry

   1. Remove the cover from the power supply with one of the following procedures:

      a. On newer models, simply remove the 4 holding screws underneath the power supply

      b. On some models, drill into the pop rivets with a 5/32" bit, then remove the pop rivets along with the 8 holding screws

         (**CAUTION:** When you use a drill, wear proper eye protection.)

   2. Find the black plastic strain-relief device attached to the cover, press it in to release pressure, and then remove it and lay it aside in a safe place

JOB SHEET #2

3. Slide the power supply cover out of the way and place the side where it will not contact any other computer parts and cause a short

4. Refer to OEM technical information or to Computerfacts for the proper waveforms and voltages for the components in the power supply

5. Plug the power supply connector back into the main board because the power supply has to be under load before it can be properly checked

   (**CAUTION:** From this point on, you're exposed to dangerous AC line voltages and it is highly recommended that you use an isolation transformer to protect yourself and your test instruments.)

6. Plug the AC power cord back into the power supply and then plug the cord into an AC power outlet

7. Check the fuse to make sure it is okay

8. Record your findings in your troubleshooting log as you make the following circuitry checks:

   a. If the fuse is not okay, replace it

   b. If the fuse is okay and there are no supply voltages, then set up the oscilloscope and check any of the oscillating waveforms in the switching power supply side of the system to see if the switcher is working

   c. If proper switching waveforms are not present, check the switching transistors first because it is most likely that the solid state components are the ones that will be damaged

   d. If solid state components are bad, replace as required and this should correct problems in the switching side of the power supply

   e. If some voltages are present, then the switching part of the power supply is probably okay because all voltages have to be missing for the switching side to not work

   f. If the +5V power source fails to function, the feedback going to the switching regulator will be missing and the switching regulator will not work

      (NOTE: If there is only one or two voltages missing, chances are it is not the +5V voltage because if this is not present the entire circuit will malfunction.)

   g. If the +12V power source is missing, then it is possible that the voltage shutdown circuit is not functioning correctly because the +12V circuit has a transistor shutdown circuit built into it

JOB SHEET #2

h. If the +5V power source is present and the +12V power source is not, chances are the problem is with the shutdown circuit or with the diode in the +12V secondary

i. If both negative voltages are missing, chances are a filter capacitor is shorted or a diode rectifier is faulty because this system uses a fairly straightforward halfway rectifier circuit

j. If any one of the many bypass capacitors used with the TTL circuitry fail because of a short, it will take that particular part of the power supply to ground

k. If one section of the power supply is shorted out and the problem does not appear to be in a power supply component, then it may require searching the board for a shorted bypass capacitor

(NOTE: Finding a shorted bypass capacitor is a time-consuming activity, but fortunately they do not short out very often.)

9. Record your findings in your troubleshooting log, then sign off the log

10. Have your instructor check your log, and make component replacements only after discussing your findings with your instructor

11. Unplug the power cord to the power supply

12. Disconnect the power supply connector to the main board, put the cover back on the power supply, and reconnect the power supply connector to the main board

13. Return tools and equipment to proper storage areas or prepare for next job sheet as directed by your instructor

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

JOB SHEET #3 — TROUBLESHOOT THE MAIN BOARD ON AN APPLE MICROCOMPUTER

A. **Tools and equipment**

1. Oscilloscope, dual-trace, minimum 60 MHz
2. DVOM
3. Logic probe
4. Logic pulsar
5. Current tracer
6. OEM schematic or Computerfacts™
7. Troubleshooting log and pencil

B. **Routine #1 — Checking the power supply and clock functions**

1. Sign on your troubleshooting log and prepare your DVOM
2. Measure all power supply voltages as outlined in Job Sheet #2
3. Make a random check at some of the power supply pins in the IC circuits to make sure proper voltages are being carried to all the circuitry
4. Validate power supply voltages and then check clock and timing functions with the following procedure:
    a. Set up the dual-trace oscilloscope with the horizontal trace speed to match the operation frequency of the microprocessor clock

    (NOTE: The operation frequency is in the 1 MHz range, but check OEM data or a reliable schematic to be certain.)

    b. Check the $\phi 1$ output on pin 3 and the $\phi 2$ output on pin 39 to validate the frequency of the clock

    c. Put 01 on one trace and 02 on the other trace to evaluate both frequency and phase relationship because the two phases should be nonoverlapping

    d. Check the frequency at pin 37

    e. If the proper frequency is not present at pin 37, then check the 14 MHz crystal oscillator

JOB SHEET #3

f. If the frequency is present at the crystal oscillator, then check the divider network to see where the frequency signal is lost

g. Replace components as required to get the proper incoming frequency at pin 37

h. If the frequency is available at pin 37 but not available at pins 3 and 39 then replace the microprocessor

(NOTE: The 6502 chip has the actual clock generator integrated into the chip and the microprocessor has to be replaced to correct this particular problem.)

i. Test the microcomputer for proper operation

j. If the microcomputer does not work at this point, check the socket and surrounding circuitry for damage and replace as necessary

k. Test the microcomputer for proper operation because if the preceding activities have solved the problem, there is no need for further troubleshooting

1. Enter your findings in your troubleshooting log and discuss your findings with your instructor

m. Repeat any part of routine #1 as required and check the following when you are relatively sure:

☐ Power supply voltages are validated

☐ Clock and timing functions are validated

n. If the microcomputer will not operate at this point, the next logical step is to check the 3 interrupts in the 6502 microprocessor

C. **Routine #2 — Checking interrupts**

1. Locate on the schematic the pin numbers for all of the interrupts

2. Check each of the interrupts to make sure it is not being held at a low logic level:

a. If any one of the interrupts is held low, the microprocessor will usually not operate because it is in a perpetual "reset" state

b. If an interrupt line is held low, trace back to the origin of the low signal or ground and remove the ground because this is usually the problem

JOB SHEET #3

c. If the RESET line, pin 40, is held low this may indicate that the restart timing circuit in the system is faulty

d. Check the 555 IC timer in the restart circuit first

e. If the 555 timer is okay, then check the associated .1 microfarad capacitor

3. Replace components as required to place all interrupts in a high state which is required for normal system operation

4. Enter your findings in your troubleshooting log and discuss your findings with your instructor

5. Repeat any parts of routines #1 and #2 as required, and check the following when you are relatively sure:

   ☐ Power supply voltages are validated

   ☐ Clock and timing functions are validated

   ☐ Interrupts are validated at normal high levels

6. If the microcomputer will not operate at this point, the next logical step is to check the ROM circuits

D. **Routine #3 — Checking ROM circuits**

1. Check to make sure proper operating voltages are available at the ROM power supply pin (Vcc pin #24), and make sure this reading is made at the supply pin and not on the PC board

2. Check for 7 ROM's that are labeled other than 2513:

   a. The ground on each of these 7 ROM's can be found on pin 12

   b. With the ground on pin 12 and the free probe on the Vcc power supply at pin #24, the reading should be +5V

   c. If there is a 2513 ROM, it will be grounded on pin #10 which when checked with pin #24 should give a reading of +5V

   d. On the 2513 ROM, checking the ground from pin #10 to pin #1 should give a reading of -12V, and checking the ground from pin #10 to pin #12 should give a reading of -15V

   (NOTE: Finding a reading of -15V means that it must come from a special power supply source which is unique to the 2513 ROM which will normally not be in the ROM setup because it is add-on circuitry that comes with a numeric keypad, but if you run into a 2513, this information will help you handle it properly.)

JOB SHEET #3

3. Validate all ROM voltages, and then check the logic levels of the ROM chips themselves

4. Make sure you have a schematic showing the proper logic levels so your checks will be accurate

5. Record all logic level checks ROM by ROM in your troubleshooting log

6. Replace any ROM that has a faulty logic level on any pin

7. Try to operate the microcomputer at this point

8. If it does not operate, make another careful check of the logic levels, and if these are okay, then check the decoder and PC wiring that supports ROM

9. If the decoder does not have a proper logic level in relation to the pins it serves, then replace the decoder chip

10. If replacing the decoder chips doesn't solve the problem, check the associated socket and wiring and replace as needed

11. Enter your findings in your troubleshooting log and discuss your findings with your instructor

12. Repeat any parts of routines #1, #2, or #3 and check the following when you are relatively sure:

    ☐ Power supply voltages are validated

    ☐ Clock and timing functions are validated

    ☐ Interrupts are validated at normal high levels

    ☐ ROM circuits are validated

13. If the microcomputer will not operate at this point, the next logical step is to check RAM circuits

E. **Routine #4 — Checking RAM circuits**

1. Check first to see if correct voltages are present at the power supply and ground locations on RAM

2. Check the power supply at pin #9 for +5V, and with pin #16 as ground, pin #1 should read -5V and pin #8 +12V (readings may vary + or -)

JOB SHEET #3

3. Validate supply voltages, then check the logic levels around the 4116 RAM chip only after referencing a good schematic:
    a. If the logic levels are not okay, check the RAM decoders and their associated sockets and PC wiring (There are several decoders)
    b. If the logic levels are okay, check to see if the system is operational or partially operational
    c. If the system is even partially operational, run a commercially available diagnostic program to quickly find the remaining faulty RAM locations
    d. If a diagnostic program is not available or the system will still not operate at all, then substitute RAM chips
4. Swap the entire 8 RAM chip blocks with another entire 8 RAM chip set and if the problems change places, then the RAM block is obviously faulty
5. Take extra RAM chips and perform a half-splitting routine by replacing 4 RAM chips, then 2, then 1, until you find the specific faulty chip
6. Enter your findings in your troubleshooting log and discuss your findings with your instructor
7. Repeat any parts of routines #1, #2, #3, and #4 as required and check the following when you are relatively sure:
    - ☐ Power supply voltages are validated
    - ☐ Clock and timing functions are validated
    - ☐ Interrupts are validated at normal high levels
    - ☐ ROM circuits are validated
    - ☐ RAM circuits are validated
8. If the microcomputer will not operate at this point, the next logical step is to check I/O circuitry

F. **Routine #5 — Checking keyboard I/O**

1. Determine which I/O device is probably at fault and start with that part of the system (this particular routine assumes keyboard problems)
2. Check first for mechanical problems or if the problem is isolated with one key that can be cleaned or replaced

JOB SHEET #3

3. Check next to make sure the keyboard encoder is firmly connected and that all contacts are properly seated onto the keyboard because there is potential for electromechanical failure at this location

4. Validate all connections, then remove the keyboard from the encoder and examine the solder connections and the PC boards on the keyboard and the encoder board

   (NOTE: The keyboard will accept almost all of the mechanical shock transmitted to the system during normal use, but prolonged use can be abuse so check this area carefully.)

5. Determine that none of the keys work, and then start checking the keyboard encoder and its associated circuitry

6. Check the few components on the encoder board, but remember that the real load here is carried by the single chip microcomputer, the 8041, and troubleshooting this chip should follow the same routines used with the kernel system in the 6502:

   a. Check power supply voltages

   b. Check output from the 8041 on the lines that strobe and constantly read the keyboard, and make this check with an oscilloscope

   c. Validate voltages, then check waveforms against the schematic

   d. If waveforms do not appear, replace the 8041 encoder chip

   e. If replacing the 8041 doesn't solve the problem, substitute a spare decoder board to quickly determine if the problem is in that area

      (NOTE: The encoder board is very hard to reach for troubleshooting, so when a spare decoder board is used, and it is known to be good, and the problem doesn't change, then the encoder board is probably okay and you can move to another area without wasting a lot of time with a hard to reach component.)

   f. If substituting a spare decoder board solves the problem, check the faulty decoder board at the important locations where waveforms can be evaluated on an oscilloscope and compared with the schematic to isolate the problem

   g. If a wrong waveform shows up, replace the component associated with the improper waveform, and this may mean the 8041 interface chip or any of the lines associated with reading the keyboard on that same chip

   h. If replacing associated components doesn't solve the problem, replace the 8041 encoder chip

JOB SHEET #3

7. Check auxiliary signals associated with timing, the repeat key, and the shift function by comparing waveforms with the schematic:
    a. These auxiliary functions may be part of one of the 74LS00 TTL chips, so if these chips are suspect, replace both of them
    b. If the waveforms are okay and auxiliary functions work but fail to reach the rest of the system, then replace the 74LS04 hex buffer because this component buffers the information going from the 8041 into the main board
    c. If replacing chips for auxiliary functions doesn't solve the problem, check their associated sockets and PC wiring
    d. If the system still won't work, the problem may be on the main board in one of the two 74LS257 multiplexers or the EP8304 transceiver
    e. Replace the multiplexers or the transceiver as required
8. Enter your findings in your troubleshooting log and discuss your findings with your instructor
9. Repeat any parts of routines #1, #2, #3, and #4 as required and check the following when you are relatively sure:
    - ☐ Power supply voltages are validated
    - ☐ Clock and timing functions are validated
    - ☐ Interrupts are validated at normal high levels
    - ☐ ROM circuits are validated
    - ☐ RAM circuits are validated
    - ☐ Keyboard I/O is validated
10. If the microcomputer will not operate at this point, the next logical step is to continue checking I/O circuitry

G. **Routine #6 — Checking tape and audio I/O**

1. Check all positive and negative voltages to the 741 OP-AMP (this routine assumes a tape and/or audio problem)

    (NOTE: This is the most likely component to fail in this part of the circuit because it is a linear component subject to drift and overload problems.)

JOB SHEET #3

2. Place a programmed cassette on the cassette player and feed the program through the tape input jack at the back of the system

3. Set up the oscilloscope, then start the tape program and evaluate both the input and output of the MC1741 OP-AMP where pin #7 should read +5V and pin #4 -5V

   a. If the signal is not getting to the MC1741 OP-AMP, the problem is probably in the jack or the RC network feeding the OP-AMP so check both

   b. If the signal is getting to the OP-AMP but not out of the OP-AMP, then the problem is in the OP-AMP chip and it should be replaced

   c. If the signal coming out of the OP-AMP is correct, then the next logical component to check is the 74LS251 multiplexer

   d. If the proper signal is coming in from the OP-AMP to pin #4 input of the multiplexer, but the signal is not present at pin #5 output of the multiplexer, then replace the multiplexer

   e. If replacing the multiplexer doesn't solve the problem, the quad timer NE558 which sends information to the multiplexer may not be generating the proper timing pulse, so check it and replace it if it is faulty

   f. If there is a sound problem with the system, the 74LS251 multiplexer also serves the audio section of the system, so replacing the multiplexer might automatically solve any audio problem if there is both a tape and an audio problem

4. Check for audio problems with a basic language "beep" program looped to create a constant test signal for monitoring:

   a. Monitor the signal with an oscilloscope back through the audio amplifier or the MPSA13 transistor known as the Darlington pair, and this is almost always the point of audio problems

   b. If replacing the Darlington pair doesn't solve the audio problem, then check back through the flip-flop and all the way back to the 74LS138 decoder and replace components as required

5. Enter your findings in your troubleshooting log and discuss your findings with your instructor

JOB SHEET #3

6. Repeat any parts of routines #1, #2, #3, #4, and #5 as required and check the following when you are relatively sure:

   ☐ Power supply voltages are validated

   ☐ Clock and timing functions are validated

   ☐ Interrupts are validated at normal high levels

   ☐ ROM circuits are validated

   ☐ RAM circuits are validated

   ☐ Keyboard I/O is validated

   ☐ Tape and audio I/O is validated

7. If the microcomputer will not operate at this point, the next logical step is to continue checking I/O circuitry

H. **Routine #7 — Checking video I/O**

1. Use the video display unit as your first troubleshooting tool if it is even partially working because this can offer good clues as to where the real problem lies (this routine assumes a video problem)

   a. The presence of a raster and no picture would indicate that the syncronization circuits are okay but something is wrong with the video picture information system

   b. If the picture is present and scrolling, then there is a problem with vertical sync

   c. If the picture is present, but torn, then there is a problem with horizontal sync

   d. If there is a lack of color, there is probably a problem in the color burst section

2. Evaluate the problem as best as possible from screen information when it is available and start your troubleshooting at that point in the video system, but when you're not sure of the problem, start from scratch

3. Start a check to determine the presence or lack of the composite video signal at specific points in the system:

   a. If the composite video signal is present at the RCA jack at the back of the system, look elsewhere for the problem

JOB SHEET #3

b. If the signal is present at the auxiliary video output but not present at the 2N3904 video output, then the RCA jack or the RLC network at the output of the board is faulty and should be checked

c. Use the oscilloscope from this point on, compare waveforms with the proper ones on the schematic, and trace back to where the video comes in from the F9334 latch because this is one of the main video paths from the latch forward

d. If the signal does not appear at the output of the latch, go back to the input of the latch and check for an incoming signal

e. If the signal is present at the input but not present at the output, then replace the F9334 latch

f. In addition to the composite video signals, there is also a color reference signal which takes a slightly different path to the video output

g. Refer to your schematic and trace the color reference signal and replace components as required

(NOTE: If you're working with the Computerfacts C1 schematic, beware that the part of the circuit that picks up the video information from memory is shown on a separate page, so you need to reference this separate page as well as the basic schematic.)

4. Check for sync problems with the following routine:

a. Locate the crystal control oscillator and follow it to the series of 74LS161 decade counters that are used to divide the basic timing signal to provide information for synchronizing both vertically and horizontally

b. Check for the lines that bring in both the horizontal and vertical signals, and these should be labeled H3, H4, and H5, and V0, V1, V2, V3, V4, and V5

c. Signals on the H and V lines are combined by logic circuitry on the main board to create the horizontal and vertical sync components found in the composite video output, so these signals demand careful examination

d. Trace these H and V signals with an oscilloscope at the point where the frequencies are divided at the decade counters

e. Continue tracing on through the logic to the summing point which is located at the input of the 2N3904 video output transistor, and at this point both the composite video signal and the sync signals can be validated on the oscilloscope

f. The lack of the appropriate signals at any point indicates a faulty component that should be replaced

g. If replacing suspected faulty components doesn't solve the problem, be sure to check sockets or PC wiring associated with the components

JOB SHEET #3

5. Record your findings in your troubleshooting log, sign off your log, and discuss your findings with your instructor

6. Repeat any parts of routines #1, #2, #3, #4, #5, #6 and #7 and check the following when you are relatively sure:

   - ☐ Power supply voltages are validated
   - ☐ Clock and timing functions are validated
   - ☐ Interrupts are validated at normal high levels
   - ☐ ROM circuits are validated
   - ☐ RAM circuits are validated
   - ☐ Keyboard I/O is validated
   - ☐ Tape and audio I/O is validated
   - ☐ Video I/O is validated

7. Check the system for proper operation, and if it still fails to operate properly at this point, review the troubleshooting log, reevaluate the problem, and repeat any routines or parts of routines as required

8. Have your instructor check and evaluate your main board troubleshooting

9. Return tools and equipment to proper storage areas and leave the work area clean

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. An electronic device that converts a binary or other coded number into a decimal number

______b. An electronic device that converts a decimal number into a binary or other coded number

______c. Original equipment manufacturer

______d. Printed circuit

______e. By chance or in no specific order

______f. Transistor, transistor logic

______g. Video display unit

1. PC
2. Random
3. VDU
4. Decoder
5. TTL
6. Encoder
7. OEM

2. Solve the following problems concerning troubleshooting the power supply.

a. What is the first power supply check?

Answer ____

b. In addition to checking and validating all power supply voltages, what else should be done at the time voltages are checked?

Answer ____

3. Complete the following statements concerning other power supply checks by inserting the word(s) that best completes each statement.

a. Validate all power supply voltages then make ____________ voltages checks at ____________ ____________ in the system

b. Check power voltages at the ____________ in random locations

c. Check power voltages at random ____________ locations

d. The presence of proper voltages is an indication that the power supply distribution bus is ____________ and the trouble is ____________ ____________

TEST

4. Solve the following problems concerning troubleshooting the clock.

   a. What are the first clock output signals that should be checked?

   Answer ______________________________

   b. If clock output signals are not correct, what is the next logical thing to check?

   Answer ______________________________

5. Complete the following statements concerning repairing a faulty clock by inserting the word(s) or figure(s) that best complete each of the following statements.

   a. Troubleshoot and ____________ the problems as previously outlined

   b. Replace any ____________ ____________ that can be replaced

   c. ____________ joints as required

   d. Replace ____________ if required

   e. Complete repairs and check again at the microprocessor for proper waveforms at ____________, ____________, and ____________

   f. If the check validates proper signals at the ____________, test the system to see if it works

6. Solve the following problems concerning troubleshooting control lines.

   a. What happens when interrupts are held at a low logic level?

   Answer ______________________________

   b. If the $\overline{\text{RDY}}$ or memory read line is at a low logic level, what happens?

   Answer ______________________________

   c. What voltage reading would probably indicate that interrupts or the $\overline{\text{RDY}}$ line are at logic high?

   Answer ______________________________

7. Arrange in order the steps in determining when to substitute a microprocessor by writing the correct sequence number in the appropriate blank.

   _____a. Attempt to operate the system

   _____b. Check clock and timing and correct as necessary

TEST

_____c. Check control lines and correct as necessary

_____d. If the system does not operate at this point, it is time to temporarily replace the microprocessor with a known good microprocessor to assure that the problem is not in the microprocessor chip

_____e. If the system does not operate after substitution of a known good microprocessor, then system memories should be checked starting with ROM

_____f. Check power supply voltages and correct as necessary

8. Solve the following problems concerning troubleshooting ROM.

   a. What could be done to solve a ROM problem when two identical microcomputers are available?

   Answer ____

   b. What is the procedure once a faulty ROM is identified?

   Answer ____

9. Solve the problems concerning troubleshooting RAM.

   a. What is the quickest way to check RAM?

   Answer ____

   b. If RAM has been checked and appears to be good, but the system is still down, what's the next move?

   Answer ____

10. Complete the following statements concerning troubleshooting I/O functions by inserting the word(s) that best completes each statement.

    a. When a peripheral device is working, especially the keyboard, it is possible to evaluate I/O functions by encoding a ____________ ____________

    b. In order to write a short test program, the troubleshooter must know the ____________ ____________ for the various parts of the system and the ____________ ____________ for the microprocessor

    c. If a test program cannot be written or run, other I/O checks for the Apple can be checked in other ways, and these include only two significant I/O devices:

       1) The ____________

       2) The ____________ terminal

TEST

11. Complete the following statements concerning characteristics of the keyboard and interface components by inserting the word(s) that best completes each statement.

    a. The keyboard and its interfacing components for this computer include:

        1) A universal peripheral interface ____________ ____________, usually an Intel 8041, but sometimes from a second source

        2) Timer and ____________

        3) ____________

        4) ____________

        5) ____________

        6) One 8-bit ____________ register

        7) Two 8-bit ____________ registers for asynchronous activity

    b. The 8041 encodes the information from the keys to the 6502 microprocessor so the 6502 is freed of that function and can work ____________

    c. Along with the keyboard encoder, there are ____________ that ____________ the signals from the encoder into a multiplexer, and that information is then sent to a transceiver which in turn sends it to the microprocessor data lines

    d. Since the data bus must be used for things other than reading the keyboard, the transceiver sends information to and from the microprocessor data line and to all other parts of the system that need to exchange data with the ____________

    e. Between the keyboard and the microprocessor are four basic parts:

        1) ____________

        2) Three-state ____________ which control the timing of various parts sending information into the transceiver

        3) ____________ which increases the signal/strength out of the 8041

        4) The 8041 which receives input ____________ from the keyboard, encodes it, and sends it to the microprocessor

12. Solve the following problems concerning troubleshooting the keyboard and components.

    a. What is the simplest troubleshooting routine for a keyboard problem?

       Answer ____

       ____

TEST

b. If a known good keyboard and encoder solve a keyboard problem, does that mean that the old keyboard and encoder are totally bad and should be thrown away, and if not, why not?

____

____

13. Complete the following statements concerning time-saving routines for troubleshooting a keyboard by inserting the word(s) that best completes each statement.

a. ____________ ____________ can be used effectively to troubleshoot a keyboard, but the different signatures for each key closure have to be available for reference

b. When the system is operating to a point that disk information can be screened, the easiest troubleshooting routine is to use a ____________ ____________ floppy disk for a key by key analysis of keyboard performance

14. Solve the following problems concerning troubleshooting video I/O.

a. What's the best way to determine if the trouble is in the video display unit?

Answer ____

____

b. What's the next procedure if substituting a known good monitor produces a blank or a black screen?

Answer ____

____

c. What's the next procedure if the substituted monitor works?

Answer ____

____

15. Complete the following statements concerning troubleshooting video components by inserting the word(s) that best completes each statement.

a. Other than the video picture content, the remainder of the video signals are generated in the stages ____________ preceding the composite video output

b. The best approach is to check the ____________ output of each of the stages producing the various parts of the composite video signal

TEST

c. When an improper ____________ is detected, keep tracing back in that same circuit until you find the place where the ____________ signal appears

d. When you find a normal signal going ____________ a component, then check the ____________, and if the normal signal is missing at the ____________, replace that component

e. When tracing the circuit component by component does not reveal the source of the problem, then carefully examine the ____________ and ____________ ____________

16. Complete the following statements concerning troubleshooting video color problems by inserting the word(s) that best completes each statement.

a. If there is a video signal but no color, the section identified as the ____________ ____________ on the schematic should be checked

b. Loss of color in the video may also be caused by a failure in the ____________ ____________ signal and the associated logic components or failure in a resistive part of that circuitry

c. Identify the color-related signals on the schematic and use an ____________ to check for proper ____________

d. Finding and replacing the component that has proper signal ____________ and an improper signal ____________ will usually solve the problem if it reaches this far into the video section

e. Pay special attention to the schematic for pin numbers where ____________ and ____________ can be verified and check both carefully as well as the associated circuitry

17. Solve the following problems concerning troubleshooting audio problems.

a. Since troubleshooting audio may require a constant signal for monitoring, how can this best be accomplished?

Answer ____

____

b. Where are many audio problems found within the audio circuitry?

Answer ____

____

TEST

18. Solve the following problems concerning troubleshooting cassette tape I/O.

    a. The heart of the cassette tape drive is basically two components, so what are they?

    Answer ______________________________

    ____

    b. If there is also no sound on the system you are troubleshooting, would this help suggest a solution to the cassette tape problem, and if so, why?

    Answer ______________________________

    ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

19. Demonstrate the ability to:

    a. Prepare an Apple microcomputer for troubleshooting. (Job Sheet #1)

    b. Troubleshoot the power supply on an Apple microcomputer. (Job Sheet #2)

    c. Troubleshoot the main board on an Apple microcomputer. (Job Sheet #3)

TROUBLESHOOTING THE APPLE II® MICROCOMPUTER
UNIT VII

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 7
   d. 1
   e. 2
   f. 5
   g. 3

2. a. For loose connections and burned components
   b. Record the readings in a troubleshooting log

3. a. Random, other points
   b. CPU
   c. Memory
   d. Okay, somewhere else

4. a. The ϕ1 and ϕ2 clock outputs
   b. The ϕ1 clock input on the CPU

5. a. Isolate
   b. Faulty component
   c. Resolder
   d. Socket
   e. ϕ0, ϕ1, ϕ2
   f. Microprocessor

6. a. They can prevent the entire system from operating
   b. The microprocessor is put on hold and it stops the system
   c. 3.5V

7. a. 4
   b. 2
   c. 3
   d. 5
   e. 6
   f. 1

8. a. The ROM can be switched to see if the trouble moves to the second system
   b. Replace it with a known good ROM

9. a. Boot system up and check RAM with diagnostics
   b. Go back to the decoding system that decodes the memory lines

10. a. Test program
    b. Memory location, machine code
    c. 1) Keyboard
       2) Video terminal

ANSWERS TO TEST

11. a. 1) 8-bit microprocessor
  - 2) Clock
  - 3) ROM
  - 4) RAM
  - 6) I/O
  - 7) Status
  - 8) Data
- b. Faster
- c. Buffers, buffer
- d. Microprocessor
- e. 1) Transceiver
  - 2) Multiplexers
  - 3) Buffer
  - 4) Directly

12. a. Substitute a known good keyboard and encoder
- b. No because the encoder may be good and the keyboard bad or vice versa, so the old components should be checked individually by half-splitting

13. a. Signature analysis
- b. Keyboard diagnostic

14. a. Substitute a known good monitor
- b. Video components will require troubleshooting
- c. Use an oscilloscope to check the composite video signals

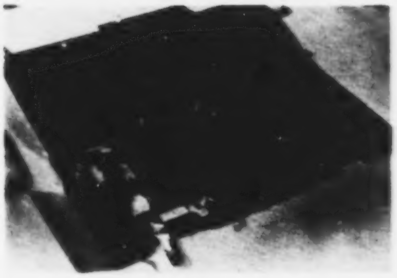
15. a. Immediately
- b. Waveform
- c. Waveform, correct
- d. Into, output, output
- e. Socket, circuit wiring

16. a. Color killer
- b. Color reference
- c. Oscilloscope, waveforms
- d. Input, output
- e. Luminescence, tint

17. a. Write a BASIC program loop that will "beep" the system constantly
- b. In the Darlington pair transistor

18. a. An MC1741 op-amp and a 74LS251 multiplexer
- b. Yes because the multiplexer also serves the sound system and the lack of sound and a cassette problem together indicates a faulty multiplexer

19. Performance competencies evaluated according to written procedures in the job sheets



TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss basic system components and characteristics of C-64 microcomputers. The student should also be able to troubleshoot a C-64 power supply and the C-64 main board. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Complete statements concerning basic system characteristics of the C-64.
2. Complete statements concerning C-64 component characteristics.
3. Solve problems concerning tips for initial troubleshooting.
4. Solve problems concerning special problems in troubleshooting the C-64.
5. Solve problems concerning how to evaluate C-64 board repair charges.
6. Demonstrate the ability to:
    a. Troubleshoot the power supply and check operating voltages on a C-64 microcomputer. (Job Sheet #1)
    b. Troubleshoot the main board on a C-64 microcomputer. (Job Sheet #2)

TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss information sheet.

D. Discuss and demonstrate the procedures outlined in the job sheets.

E. Make a special demonstration of how to properly remove IC chips that are soldered to boards, and demonstrate the proper use of staggering soldering iron movement to help eliminate overheating.

F. Invite a local or area service person who is familiar with the C-64 to talk about troubleshooting and repair items that are unique to the Commodore.

G. The schematic from OEM materials is helpful in troubleshooting the C-64, but Computerfacts™ CC4 is recommended as the best source for in-depth troubleshooting, so demonstrate the use of the Computerfacts™ and encourage students to reference it properly.

H. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

  1. Job Sheet #1 — Troubleshoot the Power Supply and Check Operating Voltages on a C-64 Microcomputer

  2. Job Sheet #2 — Troubleshoot the Main Board on a C-64 Microcomputer

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Commodore User's Guide*. Wayne, PA 19087: Commodore Business Machines, Inc., 1982.

B. *Commodore Programmer's Reference Guide*. Wayne, PA 19087: Commodore Business Machines, Inc., 1982.

C. *Computerfacts™ CC4*. Indianapolis, IN 46206: Howard W. Sams & Co., Inc., 1985.

TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

INFORMATION SHEET

I. **Basic system characteristics of the C-64**

A. The C-64 is built around a 6510 microprocessor

B. The 6510 is a newer version of the 6502 microprocessor that retains the effective features of the 6502 but has an added parallel port which is used to run the C-64 datasette system

C. The 6510 has three programs in ROM:

1. Basic interpreter
2. Operating system or kernel ROM
3. Generator ROM for graphic characters

D. The C-64 contains a sophisticated video generator chip, a 6567, which produces color, sync, and most of the video that can be accomplished by a normal TV set

E. The C-64 also generates sophisticated audio patterns with an almost self-contained sound interface device referred to as the SID chip

F. The C-64 addresses 64K of memory with an overlay scheme within the system that allows the use of various sections of memory at the appropriate time so they won't interfere with each other or be addressed at an inappropriate time in a program

G. The system has its own RF modulator designed to be used with a TV set, so if a video monitor is used it requires a demodulator component

II. **C-64 component characteristics**

A. The keyboard is a mechanical contact, tactile feedback type so that the user feels the contact when a key is pressed

B. The power supply is external to the system, and this serves some positive ends:

1. Bulk and weight are eliminated from the case
2. Noise problems with 60 Hz C power are diminished
3. Power supply troubleshooting is simplified

INFORMATION SHEET

C. Mass storage devices with the C-64 include:

  1. A cassette tape recorder/player called a "datasette" which is connected to the back of the case with a DIN connector

  2. A 1541 disk drive which is unique because it is a serial disk drive

D. The C-64 has program expansion ports on the back of the case where additional ROM can be added in the form of cartridges to expand program capability

III. Tips for initial troubleshooting

A. The C-64 external power supply has exhibited a high failure rate in the past and this is a good place to begin troubleshooting

B. Since the C-64 has two circuits, never assume that the power supply is okay if the system ON lamp lights up because the second circuit that runs the remainder of the board may be out

C. There is a system fuse internal to the system and this fuse can sometimes be burned out if the system is connected while the system switch is ON

D. Never trust a visual inspection alone for evaluating the system fuse because it is safer to pull it out and check for zero or low resistance with a DVOM

IV. Special problems in troubleshooting the C-64

A. Many of the replacement chips required for C-64 repair are not marketed through normal channels, so substituting chips on the main board will usually require having another properly operating C-64 available

B. Technical information for the C-64 is somewhat limited, so troubleshooting should not be attempted without Computerfacts™ CC4 or a comparable schematic

C. The C-64 does not have a system bus so all voltage and logic readings have to be taken around the major IC chips or at selected points in the system

D. The C-64 board is extremely sensitive to desoldering/soldering temperatures, and any chips desoldered should be replaced with sockets so the board will not be subjected to heat in future troubleshooting

INFORMATION SHEET

V. **How to evaluate C-64 board repair charges**

A. The standard charge for a new main board for the C-64 is about $55

B. Since working on the C-64 board is risky at best, it is wise to estimate as soon as possible what repair costs will be

C. Should troubleshooting time and replacement costs come near or exceed $55, recommend the customer replace the main board

TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

JOB SHEET #1 — TROUBLESHOOT THE POWER SUPPLY AND CHECK OPERATING VOLTAGES ON A C-64 MICROCOMPUTER

A. Tools and equipment

1. DVOM
2. C-64 as selected by instructor
3. Service manual or Computerfacts™ CC4
4. Basic hand tools
5. Soldering/desoldering tools
6. Pencil and troubleshooting log

B. Procedure for checking the power supply

1. Date and initial your troubleshooting log and enter your start time
2. Unplug the power supply from the AC power source and from the system
3. Set the DVOM for AC and a range that will measure under 12V
4. Plug power supply back into AC power source
5. Connect one DVOM lead to pin #6 and the other DVOM lead to pin #7 on the power supply connector CN7
6. Check for a reading of 10.9V AC
    a. If the 10.9V reading is present, move on to next check point
    b. If the reading is not okay, replace the power supply because it is a sealed unit and cannot be repaired
7. Set the DVOM for DC and a range that will measure under 12V
8. Connect one DVOM lead to GND at pin #2 and the other DVOM lead to pin #4 on supply connector CN7 (Figure 1)

JOB SHEET #1

9. Check for a reading of 5.08V DC
    a. If the 5.08V reading is present, move on to next check point
    b. If the reading is not okay, replace the power supply because it is a sealed unit and cannot be repaired
10. Enter your findings in your troubleshooting log and have your instructor check your work

C. Procedure for removing the microcomputer case

1. Unplug all system components
2. Set the system up on edge and remove the three screws from the back of the case, then set the microcomputer upright again
3. Lift the front edge of the case upward so the case can be easily removed
4. Hold the cover so that the two connectors attached to the keyboard are accessible, and then remove both the long and short connectors
5. Set the top of the case, keyboard included, aside
6. Desolder the two copper strips so that the RF shield can be lifted up
7. Locate the fuse, the switch, and the power connector at the point where they project through the case
8. Remove the system fuse from its clip to check it, and do not trust to a visual inspection
9. Set the DVOM on the Ohm scale and check for zero resistance through the fuse
    a. If resistance is okay, reinsert the fuse and move on to the next check point
    b. If resistance is not okay, replace the fuse with a known good one
    c. Lay the static shield back in place, reconnect the long and short connectors onto the keyboard, then lay the cover back onto the chassis for a temporary reassembly
    d. Power up the system and check for proper operation because it is possible that the bad fuse was the source of the problem
10. Enter your findings in your troubleshooting log and have your instructor check your work

JOB SHEET #1

D. Procedure for checking system board voltages

1. Disassemble the cover, if required

2. Plug the power supply into an AC source and turn the system switch ON

3. Set the DVOM for AC and a range that will measure under 12V

4. Find points 6 and 7 on the board side of CN7 and place one DVOM lead on point 6 and the other lead on point 7

5. Check for a reading of 10.9V AC

6. Set the DVOM for DC and a range that will measure under 12V

7. Connect one DVOM lead to GND at point #2 on the board side of CN7 and the other DVOM lead to point #4 on the board side of CN7 and check for a reading of 5V DC

   (NOTE: Refer to Figure 1 to locate the points on the board side of CN7, and remember that the system is now under power so your voltage measurements may show a slight drop from those taken earlier.)

   a. If both AC and DC voltages are okay, move on to the next check point

   b. If voltages are not present, replace CN7 and make another system check as previously outlined in C.9., c. and d.

8. Check the power switch SW1 for DC voltage with the following procedure:

   a. Set the DVOM for DC and connect the black DVOM lead to the metal chassis shield over the cartridge slot so you'll have a good ground

   b. Locate the six leads off SW1 and place the red DVOM lead on the center SW1 lead on the far side of CN7

   c. Check for a reading of about 4.2V when switch is ON

   d. Watch for a drop to nearly zero as the switch is switched OFF

9. Check the power switch SW1 for AC voltage with the following procedure:

   a. Set the DVOM for AC and connect the black DVOM lead to pin #6 of CN7

   b. Connect the red DVOM lead to the center lead of the switch closest to CN7

   c. Check for a reading of about 10.2V AC when switch is ON

JOB SHEET #1

   d. Watch for a drop to about 4.65V when the switch is switched OFF

   e. If all SW1 voltage checks are okay, move on to the next check point

   f. If SW1 voltage checks are not okay, SW1 should be replaced and a system check completed as previously outlined in C.9., c. and d.

10. Check for DC voltage out of the on board rectifier with the following procedure:

   a. Set the DVOM for DC and connect the black DVOM lead to GND and the red lead to the positive end of capacitor C19

   b. Turn the system switch ON and check for a reading of between 10.5V and 11.77V

   c. If the rectifier is okay, move on to the next check point

   d. If the rectifier is not okay, desolder and replace it with a known good rectifier and run a system check as previously outlined

11. Check the regulated voltages out of VR1 and VR2 with the following procedure:

   (NOTE: VR1 and VR2 are the 12V and 5V regulators.)

   a. Set the DVOM for DC and connect the black lead to GND and the red lead to pin #2 of VR1

   b. Turn the system switch ON and check for a reading of close to 12V, and turn system switch OFF

   c. Leave the black lead on GND and connect the red lead to pin #2 of VR2

   d. Turn the system switch ON and check for a reading of close to 5V, and turn system switch OFF

   e. If both readings are okay, move on to the next check point

   f. If the 5V reading is missing or incorrect, desolder and replace VR2

   g. If the 12V reading is missing or incorrect, it may mean that VR1 should be desoldered and replaced or it can mean that the voltage doubler is faulty

12. Check to determine if voltage problem is with VR1 or the voltage doubler with the following procedure:

   a. Set the DVOM on DC with the black lead on GND and the red lead on pin #1 of VR1

JOB SHEET #1

b. If the reading is not close to 22V, the doubler is at fault and all components in the doubler system should be replaced

(NOTE: These components include the CR5 and CR6 rectifiers and the C90 and C19 capacitors.)

c. If the reading is close to 22V, the output on pin #2 of VR1 will not have the proper 12V reading and VR1 is faulty and should be desoldered and replaced

13. Enter your findings in your troubleshooting log

14. Sign off your troubleshooting log and have your instructor check your work

15. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

JOB SHEET #1

Troubleshooting and Repair Log

Customer's Name ______________________ Invoice ______________

Date ______________ Equipment and Serial # ______________________

Complaint ____

____

Technician's Name & ID #	Date	Time On	Time Off	Work Performed	Replacement Parts Used & Inventory #

TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

JOB SHEET #2 — TROUBLESHOOT THE MAIN BOARD ON A C-64 MICROCOMPUTER

A. Tools and equipment

1. C-64 as selected by instructor
2. Service manual or Computerfacts™ CC4
3. DVOM
4. Dual-trace oscilloscope, 60 MHz minimum
5. Basic hand tools
6. Pencil and troubleshooting log

B. Routine #1 — Checking voltages, interrupts, and timing

1. Date and initial your troubleshooting log and enter your start time
2. Unplug the system and remove the case as previously outlined
3. Place a 40-pin test clip over the 6510 microprocessor labeled U7
4. Plug the system in and turn the system switch ON

   (**CAUTION:** Work with care from this point on because throughout this procedure you'll be exposed to potentially hazardous voltages.)

5. Set the DVOM for DC and a range that will test for +5V
6. Check for +5V by placing the red lead on pin #6 and the black lead on the GND at pin #21
   a. If close to +5V is present, move on to the next check point
   b. If reading is not okay, backtrace supply lines to assure there are no problems between this point and the power supply
   c. Backtrace with the DVOM or the logic probe at all points along the trace and look for the presence of logic 1 to indicate a problem
   d. Check the 6510 socket because the problem may be electromechanical
7. Check the interrupts and other control pins while the DVOM ground lead is still connected to pin #21

JOB SHEET #2

8. Check the RESET at pin #40 for approximately +5V

9. Check NMI at pin #4 for approximately +5V

10. Check IRQ at pin #3 for approximately +5V

11. Check RDY at pin #2 for approximately +5V

    a. If all interrupts and control lines are at logic 1 (over 2.4V), move on to the next check point

    b. If any readings are not at logic 1, then check the support circuitry that supplies the signal to the specific pin that is faulty

12. Test the microcomputer, and if it still doesn't operate properly, check the clock

13. Plug in and turn on the dual-trace oscilloscope

14. Connect one of the oscilloscopes probes to pin #39 and observe the high frequency waveform

15. Verify a frequency of approximately 1 MHz

    (NOTE: A quicker way to check this would be to use a frequency meter with a probe on pin #39 and the ground on pin #21, and it should show a 1MHz reading.)

    a. If the 1 MHz is present, move on to the next check point

    b. If the reading is not correct, check the crystal oscillator for a frequency of 14.318 MHz

    c. If the crystal oscillator is not okay, desolder and replace it, and remember that desoldering on this board is always a calculated risk, so check with your instructor

    d. If the crystal oscillator is okay, then check the frequency divider circuit

    e. The divider circuit consists of the 74LS193 and 74LS629 chips which can both be checked with an oscilloscope so waveforms can be compared with the Computerfacts schematic

    f. Replace divider circuit chips as needed, but remember that desoldering and soldering will be required here, so check with your instructor

16. Check for address bus activity at pins #7 through #23 (pin #21 is GND)

    a. If using a scope, the screen should show evident activity

    b. If using a logic probe, it should blink or may stay lighted with a low-level intensity

JOB SHEET #2

17. Check for data bus activity at pins #30 through #37

    a. If using a scope, the screen should show evident activity

    b. If using a logic probe, it should blink or stay dimly lit

    (NOTE: Have your instructor show you how to interpret bus activity with the type of scope or probe that you are using, and also remember that bus activity can be evaluated with signature analysis.)

18. Test the system, and if it is working properly there is no need for further troubleshooting

19. Enter your findings in your troubleshooting log and discuss your findings with your instructor

20. Move on to the next logical check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

    ☐ Power supply voltages are verified

    ☐ Interrupts and control lines are verified at logic 1

    ☐ Clock frequency is verified

    ☐ Bus activity is verified

C. Routine #2 — Checking system ROM

1. Locate the socketed kernel ROM chip identified as U4

2. Set the DVOM for DC and a range that will check +5V

3. Check for +5V at pin #24 while ground lead is on pin #12

    a. If voltage is okay, move on to next check point

    b. If voltage is not okay, backtrace to the power supply

4. Check for address and data bus activity with the following procedure:

    a. Address bus activity should be on pins #1 through #8 and pins #18, #19, #22, and #23

    b. Data bus activity should be on pins #9, #10, #11, and #13 through #17

    c. If using a scope, the screen should show evident activity

    d. If using a logic probe, it should blink or stay dimly lit

JOB SHEET #2

- e. If the ROM fails to show activity, then substitute a known good ROM
- f. If the ROM still fails to show activity, check to see if pin #16 on logic chip U17 is at ground because U17 is the logic array that's used to decode the ROM's
- g. If pin #16 GND on U17 is not okay, substitute a known good chip

5. Test the system, and if it is working properly there is no need for further troubleshooting

6. Enter your findings in your troubleshooting log and discuss your findings with your instructor

7. Move on to the next check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are verified
   ☐ Interrupts and control lines are verified at logic 1
   ☐ Bus activity is verified
   ☐ System ROM is verified

D. Routine #3 — Checking system RAM

1. Locate the two rows of RAM chips in the lower left hand corner of the board, U9 through U12 and U21 through U24

2. Set the DVOM for DC in a range that will measure +5V

   - a. Place the DVOM ground lead on pin #16
   - b. Place the DVOM positive lead on pin #8
   - c. Check all RAM chips for a reading of +5V
   - d. If voltages are okay, move on to next check point
   - e. If voltages are not okay, backtrace to the power supply and correct any supply line problems
   - f. If voltages are apparently okay, turn the system OFF and begin substituting RAM chips one bank at a time

JOB SHEET #2

3. Replace RAM chips with the following procedure:

    a. Clip the pins on a RAM chip as close to the body of the chip as possible so there will be enough of the pin left to hold with a pair of needlenose pliers

    b. As you desolder, stagger the movement of the soldering iron so that heat will be better disbursed over that area of the board

    (NOTE: This is an extremely heat sensitive board and staggering the heat input will help.)

    (**CAUTION:** This is an extremely heat sensitive board and your instructor may not permit you to desolder or solder on the board at all.)

    c. Remove the remaining parts of the pins as they are desoldered and use a desoldering wick or a desoldering bulb to pick up the excess solder

    d. Before replacing RAM chips, place sockets in the old RAM chip locations so future troubleshooting will not require heating up the board again

    e. Place known good RAM chips in the new sockets

4. Test the system, and if it is working properly there is no need for further troubleshooting

5. Enter your findings in your troubleshooting log and discuss your findings with your instructor

6. Move on to the next check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

    ☐ Power supply voltages are verified

    ☐ Interrupts and control lines are verified at logic 1

    ☐ Clock frequency is verified

    ☐ Bus activity is verified

    ☐ System ROM is verified

    ☐ System RAM is verified

E. Routine #4 — Checking keyboard I/O

1. Determine which I/O device is probably at fault and start with that part of the system (this routine assumes keyboard problems)

JOB SHEET #2

2. Run a keyboard diagnostic disk if the system will boot up at this point, and try to determine if the problem is isolated with one key or to a few keys as opposed to an overall keyboard problem

3. Remove the 23 small Phillips screws that hold the backplate to the keyboard, but do not remove the larger screws that hold the keyboard outer rails

   (NOTE: These are small screws so be sure to place them in a container so none will get lost.)

4. Desolder the two bare wires that extend through the backplate, then slip the keyboard off the backplate

   (NOTE: Desoldering at this point is not as risky, but it should still be done with care.)

5. Use lint-free cloth wipes or some equally safe cleaning material to clean all the contact points on the inner side of the keyboard

6. Reassemble the keyboard components and resolder the wires on the backplate with special care

7. Retest the keyboard, and if it is still not functioning, then substitute a known good keyboard

   a. If the new keyboard solves the problem, move on to the next check point

   b. If there is still a problem, continue with the keyboard system check

8. Check logic levels on the keyboard decoder/encoder chip U1 to make sure they agree with the logic levels indicated in Computerfacts CC4

   a. If the U1 chip is okay, move on to the next check point

   b. If the U1 chip is not okay, desolder and replace with a known good chip

      (**CAUTION:** Use the desoldering procedure outlined in D3.)

9. Enter your findings in your troubleshooting log and discuss your findings with your instructor

F. Routine #5 — Checking tape I/O

(NOTE: The cassette function is controlled entirely by the parallel port on the 6510 microprocessor, so since the microprocessor should have already been checked, the tape I/O check is a limited procedure.)

1. Use a DVOM to check capacitor C1 and resistor R1

JOB SHEET #2

2. Use a DVOM to check the transistors Q1, Q2, and Q3 which serve as the motor drive controls

3. Check all readings against the values given in the Computerfacts schematic, and remember that you're dealing with 12V at this point

    a. If all readings are okay, move on to the next check point

    b. If readings are not okay, desolder and replace faulty components with care

4. Enter your findings in your troubleshooting log and discuss your findings with your instructor

G. Routine #6 — Checking video I/O

1. Locate the components associated with the video system

    a. The U26 latch

    b. The U15 selector which is a function selector for various auxiliary functions

    c. The U16 data switch

    d. The U6 color ROM

    e. The U19 video interface chip

    f. The U19 multiplexer

    g. The M1R modulator

2. Set up the oscilloscope and make a waveform analysis according to the waveforms shown on the Computerfacts schematic

3. Make a note of improper waveforms or the absence of any waveforms so you'll know where to begin video troubleshooting

    a. If the video system sync information is incorrect out of the U19 video interface chip, then check the logic of the video interface chip at all pins and compare it with logic given in Computerfacts

    b. If the video interface chip is not okay, replace it with a known good chip and retest video system for proper sync waveforms

    c. If system still does not have proper waveforms, backtrace to the oscillator that was validated earlier to make sure those signals are getting through to the video interface chip

JOB SHEET #2

   d. Check waveforms again, and if there are improper waveforms out of other components, then check the component associated with the improper waveform

   e. Be sure to check supply voltages and logic from tables in Computerfacts for each component suspected of being faulty

   f. If voltages and logic check out and waveform is still wrong, replace the component

4. Check the final stage of the video system, the RF modulator labeled M1

   a. If the system is operating properly at this point, there is no need for further troubleshooting

   b. If all the signals are correct coming into the M1 RF modulator, but there is still video output failure, replace the entire RF module

   (NOTE: The RF module is an FCC-approved device and no repairs should be attempted.)

5. Enter your findings in your troubleshooting log and discuss your findings with your instructor

H. Routine #7 — Checking audio I/O

(NOTE: The audio output is produced by only one part, the SID or sound interface device labeled U18 which is an almost completely self-contained system with five address lines in, as well as the full data line set D0 through D7, and also RESET, READ/WRITE and ϕ2 standard control lines from the microprocessor.)

1. Locate the audio system components that can be checked

   a. The U15 selector referenced in Routine #6

   b. The single transistor Q8 which serves as the external audio frequency amplifier

   c. If there is a complete sound failure, check the U15 logic

   d. If the U15 doesn't check out, replace it

   e. If the U15 is okay, check the voltages around the Q8 transistor along with its associated capacitors and resistors

   f. If problems are found, replace components as required

JOB SHEET #2

2. Enter your findings in your troubleshooting log and check off the routine that you have completed

    - ☐ Power supply voltages are verified
    - ☐ Interrupts and control lines are verified at logic 1
    - ☐ Clock frequency is verified
    - ☐ Bus activity is verified
    - ☐ System ROM is verified
    - ☐ System RAM is verified
    - ☐ Keyboard, tape, video, and audio I/O's are verified

3. Sign off your troubleshooting log

4. Discuss your findings with your instructor, and your instructor may ask you to complete any unchecked routines at another time or on another system

5. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TROUBLESHOOTING THE COMMODORE© 64 MICROCOMPUTER
UNIT VIII

NAME ______________________

TEST

1. Complete the following statements concerning basic system characteristics of the C-64 by inserting the word(s) that best completes each statement.

    a. The C-64 is built around a ____________ microprocessor

    b. The ____________ is a newer version of the 6502 microprocessor that retains the effective features of the 6502 but has an added parallel port which is used to run the C-64 ____________ system

    c. The ____________ has three programs in ROM:

        1) Basic ____________

        2) Operating system or ____________ ROM

        3) Generator ROM for ____________ characters

    d. The C-64 contains a sophisticated ____________ ____________ chip, a 6567, which produces color, sync, and most of the video that can be accomplished by a normal TV set

    e. The C-64 also generates sophisticated audio patterns with an almost self-contained sound interface device referred to as the ____________ chip

    f. The C-64 addresses ____________ of memory with an overlay scheme within the system that allows the use of various sections of memory at the appropriate time so they won't interfere with each other or be addressed at an inappropriate time in a program

    g. The system has its own RF modulator designed to be used with a TV set, so if a video monitor is used it requires a ____________ component

2. Complete the following statements concerning C-64 component characteristics by inserting the word(s) that best completes each statement.

    a. The keyboard is a mechanical contact, tactile feedback type so that the user ____________ the contact when a key is pressed

    b. The power supply is ____________ to the system, and this serves some positive ends:

        1) ____________ and ____________ are eliminated from the case

TEST

2) ____________ problems with 60 Hz C power are diminished

3) Power supply troubleshooting is ____________

c. Mass storage devices with the C-64 include:

1) A cassette tape recorder/player called a "____________" which is connected to the back of the case with a DIN connector

2) A 1541 disk drive which is unique because it is a ____________ disk drive

d. The C-64 has program expansion ports on the back of the case where additional ROM can be added in the form of ____________ to expand program capability

3. Solve the following problems concerning tips for initial troubleshooting.

a. Where is a good place to begin troubleshooting a C-64 and why?

Answer ____

____

b. Is a visual check of the system fuse okay, and if so, why, and if not, why?

Answer ____

____

4. Solve the following problems concerning special problems in troubleshooting the C-64.

a. What is the biggest problem with the C-64 board?

Answer ____

____

b. Why not use the system bus for checking voltages?

Answer ____

____

c. Since replacement components are not available through normal supply channels, how can chips be substituted to help speed up troubleshooting?

Answer ____

____

TEST

5. Solve the following problem concerning how to evaluate C-64 board repair charges.

   If repairing the main board would cost $62.50, what should be recommended to the customer?

   Answer ______________________________

   ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6. Demonstrate the ability to:

   a. Troubleshoot the power supply and check operating voltages on a C-64 microcomputer. (Job Sheet #1)

   b. Troubleshoot the main board on a C-64 microcomputer. (Job Sheet #2)

TROUBLESHOOTING THE COMMODORE® 64 MICROCOMPUTER
UNIT VIII

ANSWERS TO TEST

1. a. 6510
   b. 6510, datasette
   c. 6510
      1) Interpreter
      2) Kernel
      3) Graphic
   d. Video generator
   e. SID
   f. 64K
   g. Demodulator

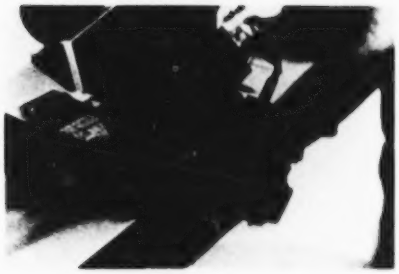
2. a. Feels
   b. External
      1) Bulk, weight
      2) Noise
      3) Simplified
   c. 1) Datasette
      2) Serial
   d. Cartridges

3. a. The power supply because it has a history of high failure rates
   b. No, because it is not totally reliable and a DVOM should be used to check for zero resistance

4. a. It is highly sensitive to soldering and desoldering
   b. There is no system bus on the C-64
   c. Have another operational C-64 available and use chips from it

5. Put in a new board because it costs about $55

6. Performance competencies evaluated according to procedure written in the job sheets



TROUBLESHOOTING THE IBM® PC
UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss system and component characteristics of the IBM® PC and list tips for troubleshooting the system. The student should also be able to troubleshoot the power supply and operating voltages and troubleshoot the main board on an IBM® PC. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Complete statements concerning system characteristics of the IBM® PC.
2. Complete statements concerning component characteristics of the IBM® PC.
3. Complete a list of materials for troubleshooting.
4. Solve problems concerning tips for troubleshooting the IBM® PC.
5. Demonstrate the ability to:
    a. Troubleshoot the power supply and operating voltages on an IBM® PC. (Job Sheet #1)
    b. Troubleshoot the main board on an IBM® PC. (Job Sheet #2)

TROUBLESHOOTING THE IBM® PC
UNIT IX

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss information sheet.

D. Discuss and demonstrate the procedures outlined in the job sheets.

E. Discuss with students the problems that can be generated with improper card selection and ways to handle such cards in troubleshooting.

F. Review the Computerfacts™ CSCS2 and point out to students how the parts of the package fit together and the value of the materials in troubleshooting.

G. Check warranties on any IBM PC's that are selected for students to work with, and make sure troubleshooting and repair activities do not invalidate warranties that may still be in effect.

H. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

   1. Job Sheet #1 — Troubleshoot the Power Supply and Operating Voltages on an IBM® PC.

   2. Job Sheet #2 — Troubleshoot the Main Board on an IBM® PC.

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Brenner, Robert C. *IBM PC Troubleshooting and Repair Guide.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1985.

B. *SAMS Computerfacts™ CSCS2 Computer: IBM® PC5150.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1985.

TROUBLESHOOTING THE IBM® PC
UNIT IX

INFORMATION SHEET

I. **System characteristics of the IBM PC**

A. The system is specifically designed to be expanded or modified to fulfill specific user needs and is not a self-contained system

B. The system is a 16-bit data word system built around the Intel 8088 microprocessor, but since it uses 8-bit data in two-byte words, it is essentially a 16-bit microprocessor that can use 8-bit data words

C. The case houses the main board and has peripheral slots for five cards for user-selected peripheral I/O functions

(NOTE: This open architecture is adaptable to many applications, but improper cards and some non-IBM cards can create real headaches with this system, and card selection can create special troubleshooting problems.)

D. The power supply is housed in the system case and is adequate for driving the system board and two floppy disk drives

E. Two spaces are provided inside the case for two standard height floppy disk drives or two half-height disk drives and one hard disk drive

(NOTE: Remember that when you're working on a system with a hard disk drive, the power supply will not be the standard system power supply, it will be a larger one because that is required for anything more than two floppy disk drives.)

II. **Component characteristics of the IBM PC**

A. The system main board contains a minimum of 64K RAM which is permanently soldered to the board, but the board contains facilities for up to 256K of 4164-type DRAM

B. The main board may contain up to 5 ROM

C. The main board also contains a built-in interface for cassette tape operations and a speaker for audio generation

D. The keyboard is provided with the basic system, but it is a separate device connected by a coil-wrapped cord so it can be used remotely from the system

E. System is sold with either a monochrome high resolution card or a color card and the user selects this option and the proper I/O card for it

INFORMATION SHEET

F. Floppy disk drives are normally part of the system and must also have a disk drive I/O card installed for proper operation

(NOTE: Troubleshooting video and disk drive I/O is simplified with this arrangement.)

III. **Materials for troubleshooting**

A. When disk drives are purchased with the system, disk-based diagnostics are included with the system

B. If no disk drive is purchased with the system, tape-based diagnostics are included with the system

(NOTE: The diagnostics provided for the system are reasonably thorough, and whether on disk or tape should be used for initial troubleshooting with all systems that will boot up.)

C. An additional maintenance and repair manual complete with a diagnostic disk is available at the time of purchase for about $150 extra

(NOTE: Some service materials for this system are intended for limited use and may not seem clear or complete to someone who has not attended an official repair school.)

D. Other troubleshooting guidelines and very helpful schematics are available in Computerfacts™ CSCS2 COMPUTER: IBM® 5150

(NOTE: This Computerfacts is recommended for use with the job sheets that accompany this unit because the schematics for the power supply and the main board will be used extensively, and the other Computerfacts schematics for both the disk drives and the disk drive I/O board and video I/O boards will be valuable if those areas require attention.)

IV. **Tips for troubleshooting the IBM PC**

A. Be very certain about the warranty status of the system you're working and do not desolder or solder or remove protected screws or rivets from systems that are still under warranty

B. Be extremely certain of what you're doing when you solder or desolder on a board because even if it is out of warranty, IBM will not work on a board that has been tampered with

C. Unlike inexpensive boards ($55 to replace the C-64 board), the PC board costs about $1000 to replace, so troubleshooting it effectively can be extremely cost effective for a customer

TROUBLESHOOTING THE IBM® PC
UNIT IX

JOB SHEET #1 — TROUBLESHOOT THE POWER SUPPLY AND OPERATING VOLTAGES ON AN IBM® PC

A. Tools and equipment

1. Microcomputer as selected by instructor
2. Computerfacts™ CSCS2
3. DVOM
4. Dual-trace oscilloscope
5. Probe set
6. Basic hand tools
7. Pencil, paper, and troubleshooting log

B. Route #1 — Removing the case

1. Date and sign on your troubleshooting log
2. Unplug the system from AC power source
3. Remove all external cables for monitor, printer, power supply, and keyboard
4. Remove the five screws at the back of the case with a ¼" nutdriver (a screw at each corner and one at top middle)
5. Lift the case a bit and slide it forward slowly until the end of the case reaches the front panel
6. Stop just as the case catches which will indicate the case has moved as far as it can
7. Lift the front of the case to a slight angle to free it, and then lift the case off
8. Place the case safely aside and be sure the five screws removed are all replaced when you replace the case because these screws form the electrical bond for the shielding of the system
9. Have your instructor check your work

C. Routine #2 — Checking the power supply

1. Turn the power OFF

JOB SHEET #1

2. Locate the power supply at the right rear corner of the case

3. Check the diagram on the side of the power supply and make notes of the voltage readings that should be present on P8 and P9, the two main board connectors, and P9 and P10, the two floppy disk drive connectors

   (NOTE: When referencing the power supply schematic in Computerfacts, place the sheet labeled 8 and 53 alongside the sheet labeled 52 and 9 so the schematic will be in the proper order.)

4. Load the power supply by placing a 47 Ohm resistor between pins #2 and #4 on floppy disk drive connector P10 and P11

5. Turn the power ON

6. Set the DVOM for DC and a range that will handle both + and −5V and 12V

7. Place the black DVOM lead on the GND at pin #5 (pins #6, #7, and #8 are all commons too) of P8

8. Place the red DVOM lead on the following pins and look for the following approximate readings:

   a. Check for a reading of +5V at pin #1

   b. Check for a reading of +12V at pin #3

   c. Check for a reading of −12V at pin #4

   d. Check for a reading of −5V at pin #9

   e. Check for a reading of +5V at pins #10, #11, and #12

9. Repeat the voltage check for the P9 connector

10. Go to the P10 floppy disk drive connector, use pin #2 or #3 as a ground, and check for the following approximate readings:

    a. Check for a reading of +12V at pin #1

    b. Check for a reading of +5V at pin #4

11. Repeat the voltage check for the P11 connector

    a. If all voltages are okay, there may be other problems causing the power supply to fail, so hook up the P8 connector to the main board and test the system

    b. If the system works, the P8 connector is not the problem, so hook up the P9 connector to the main board

JOB SHEET #1

c. If the system works, the P9 connector is not the problem, so hook up the floppy disk drive P10 connector and test the system

d. If the system works, the main board and the P10 or drive A connector are not causing the problem, so hook up the floppy disk P11 connector and test the system

e. If the system works, the main board and P10 and P11 connectors, drives A and B, are not the cause of the problem

f. If the system fails to work after any of the preceding checks, then the part of the system causing the problem requires troubleshooting, and those routines will be covered in the next job sheet

g. If voltages are not okay, the power supply will have to be replaced or repaired, so make sure the system is no longer under warranty before attempting to remove and repair the power supply

D. Routine #3 — Troubleshooting the power supply

1. Make sure the power is OFF

2. Remove the four Phillips screws that secure the power supply to the back panel of the case

3. Slide the power supply about ½" forward in the case and lift gently straight up to remove it from the case, but don't force it or you might damage it

   (NOTE: Should you be working on a system with a hard disk, the two screws holding the hard disk in place will also have to be removed to permit the power supply to come out.)

4. Use a ¼" nutdriver to remove the screws that hold the power supply cover in place

5. Rig up a hand drill with a ¼" bit and drill out the two rivets that also help secure the power supply cover

   (NOTE: Once these rivets are removed, all warranties concerning the power supply become invalid, so check with your instructor.)

6. Remove the power supply cover so that the boards inside the power supply are accessible for troubleshooting

   (NOTE: If you're working on an older system, power supply disassembly may vary because these power supplies are made by more than one vendor.)

7. Turn the power ON and work with care during the remainder of the routine because you will be exposed to high voltages

JOB SHEET #1

8. Listen for the power supply fan and make sure it is running smoothly and not making noises that would indicate a fan problem

9. Check test points #8, #9, #10, and #11 with the oscilloscope to see if the waveforms agree with those shown in the Computerfacts

   a. If waveforms are okay, move on to next check point

   b. If waveforms are not okay, the main filter capacitors may be bad and their replacement may also be related to a bad fuse, so move on to the next check point

10. Check the power supply fuse with a careful visual examination

    a. If there is any question about the fuse, turn the power OFF and replace it

    b. If the fuse is blown, check diodes CR1 and CR2 and the main filter capacitors C1 and C2 and replace as needed

    c. If the diodes and filters are okay, check the oscillator IC1 and the power transistors Q1 and Q2 that are associated with the IC1 oscillator

    (NOTE: These are switched by the oscillator.)

11. Check the waveforms from the switching system and compare them with the waveforms shown in the Computerfacts

    a. If waveforms are okay, move on to the next check point

    b. If the waveforms are improper, check the T1 and T2 transformers in the system and replace as needed

    (**CAUTION:** Once you get past the Q1 transistor, voltages are dangerously high, so work with care.)

    c. Check the T2 transformer carefully because it is the output of the switching system and supplies the various voltages for the system

    d. Output voltages from the T2 transformer may be checked with a DVOM or a scope

    e. If any one section of the transformer fails to produce the proper voltage, it is a good idea to disconnect the transformer lead associated with that part to determine if it is a transformer problem or a problem with the load on the transformer

12. Check the filter capacitors, diodes, and transistors in the output circuitry as required, and turn the power OFF

JOB SHEET #1

13. Enter your findings in your troubleshooting log and discuss your findings with your instructor

14. Reassemble the power supply and replace the rivets that were drilled out with self-threading screws

15. Reinstall the power supply and secure it in the system

16. Reconnect the P8 and P9 main board connectors and the P10 and P11 floppy disk drive connectors (if both disk drives are active)

17. Secure the hard disk if the system has one

18. Turn the system ON

19. Make a random check of supply voltages on the main board with the following procedure:

    a. Check the voltages on the B side of the system bus connector

    b. B9 should be +12V

    c. B3 and B29 should be +5V

    d. B5 should be −5V

    e. B7 should be −12V

    f. B1, B10, and B31 are all commons

20. Enter your findings in your troubleshooting log and sign off your troubleshooting log

21. Discuss your findings with your instructor

22. Replace the system case, clean up the area and return tools and equipment to proper storage

23. Conclude or continue as directed by your instructor

    a. If the power supply and operating voltages are okay and the system is still not working, your instructor may request that you prepare for the next job sheet so you can continue troubleshooting the main board

    b. If the system is working okay, your instructor may direct you to replace the case, clean up the area, and return tools and equipment to proper storage

JOB SHEET #1

Troubleshooting and Repair Log

Customer's Name ______________________________ Invoice ____________________

Date ____________________ Equipment and Serial # ______________________________

Complaint ____

____

Technician's Name & ID #	Date	Time On	Time Off	Work Performed	Replacement Parts Used & Inventory #

TROUBLESHOOTING THE IBM® PC
UNIT IX

JOB SHEET #2 — TROUBLESHOOT THE MAIN BOARD ON AN IBM® PC

A. Tools and equipment

1. Microcomputer as selected by instructor
2. Computerfacts™ CSCS2
3. DVOM
4. Dual-trace oscilloscope
5. Probe set
6. Basic hand tools
7. Pencil, paper, and troubleshooting log

B. Routine #1 — Check the 8088 microprocessor

1. Sign on and date your troubleshooting log
2. Unplug the system and remove the case as previously outlined
3. Put an IC test clip over the 8088
4. Plug the system in and turn it ON
5. Set the DVOM for DC and check supply voltages on the 8088 with the following procedure:
    a. Place the black DVOM lead on pin #1 or pin #20
    b. Place the red DVOM lead on pin #4 and check for +5V and then on pin #31 and check for +5V
    c. If the voltage is okay, move on to the next check point
    d. If the voltage is not okay, backtrace lines to the power supply and correct any problems
6. Check the clock with the following procedure:
    a. Locate the clock generator 8284 labeled U11

JOB SHEET #2

b. Use a frequency meter or a scope to check pin #19 on the 8088 for a reading of 4.77 MHz

c. If the frequency is okay, move on to the next check point

d. If the frequency is not okay, backtrace to the clock generator chip at U11 and correct any problems

e. Check pin #8 on the 8284 chip for the 4.77 MHz reading

f. If the reading is not okay, the crystal may be faulty, but chances are it's the 8284 chip, so replace it and move on to the next check point for this should correct any clock problems

7. Check the interrupts with the following procedure:

a. Check RESET at pin #21 for a reading of approximately .18V

b. Check NMI at pin #17 for a reading of approximately .18V

(NOTE: The NMI accepts input requests from both the system bus and auxiliary devices.)

c. Check INT at pin #18 for a reading of approximately .06V

(NOTE: The INT is connected to an interrupt controller chip 8259 which can expand this INT to eight interrupts.)

d. If the interrupts are okay, move on to the next check point

e. If the interrupts are not okay, backtrace the circuits that supply the TTL signals

(NOTE: This will require careful examination of the Computerfacts and careful tracing and evaluation to find the problem, so ask your instructor to help if you have any difficulty.)

8. Check activity on the address and data bus lines with the following procedures:

a. Check for address bus activity on pins #9 through #16 which are the A0 through A7 address lines that also double as data lines

b. Check for address bus activity on pins #2 through #8 which are the A8 through A14 address lines

c. Check for address bus activity on pins #35 through #39 which are the A15 through A19 address lines

d. If there is bus activity, move on to the next check point

JOB SHEET #2

   e. If there is no bus activity, substitute a known good microprocessor

   f. If the substitute microprocessor corrects the problem, move on to the next check point

   g. If the substitute microprocessor does not correct the problem, then it means the problem is somewhere else on the bus and this will be checked later in this routine

9. Enter your findings in your troubleshooting log and discuss your findings with your instructor

10. Move on to the next check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

    ☐ Power supply voltages are verified
    ☐ Interrupts are verified
    ☐ Clock frequency is verified
    ☐ Bus activity is verified

C. Routine #2 — Checking system ROM

1. Run diagnostic disk if the system will boot up the disk, and if the system will still not boot up at this point, check voltages and then substitute ROM

2. Locate the system ROM's (usually 5) and check for the following on each ROM:

   a. Check ground pin #12 for a reading of 0V

   b. Check pin #24 for a reading of +5V

   c. If voltages are okay, substitute a known good ROM for the first ROM, then check the system

   d. Substitute ROM's in order and test the system each time until all ROM's are validated or the bad ROM is found

   e. Once system ROM's have been validated or replaced as needed, check the system

   f. If the system will not work at this point, it's probably some part of the system other than ROM

JOB SHEET #2

3. Move on to the next check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are verified

   ☐ Interrupts are verified

   ☐ Clock frequency is verified

   ☐ Bus activity is verified

   ☐ System ROM is verified

D. Routine #3 — Checking system RAM

1. Run diagnostic disk if the system will boot up the disk, and if the system will not boot up the disk, continue with troubleshooting procedures

2. Remember that the 5150 board can hold up to 256K of RAM and uses the 4116-type DRAM chips

3. Examine the board carefully to make sure you locate all the RAM chips in the system

   (NOTE: All IBM PC clones use nine instead of eight RAM chips in a bank because the ninth chip is a parity-checking chip.)

4. Check voltages on each of the RAM chips with the following procedure:

   a. Place the black DVOM lead on pin #16

   b. Place the red DVOM lead on pin #8 and check for +5V

      (NOTE: The initial 64K of RAM are soldered onto the board, but all other RAM chips are socketed.)

   c. If all voltages are okay, move on to the next check point

   d. If any voltages are not okay, substitute RAM a bank at a time and test the system after each bank is substituted

   e. If any voltages are not okay on the soldered bank of RAM, desolder and replace as needed only if the system is no longer under warranty because soldering on the IBM board nullifies the warranty

   f. Once system RAMs have been verified or replaced as needed, check the system

JOB SHEET #2

   g. If the system will not work at this point, it's probably some part of the system other than RAM, so move on to the next check point

5. Enter your findings in your troubleshooting log and discuss your findings with your instructor

6. Move on to next check point if the system is not operating properly, but first reevaluate your procedure and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are verified

   ☐ Interrupts are verified

   ☐ Clock frequency is verified

   ☐ Bus activity is verified

   ☐ System ROM is verified

   ☐ System RAM is verified

E. Routine #4 — Checking keyboard I/O

1. Determine which I/O device is probably at fault and start with that part of the system (this routine assumes keyboard problems)

2. Run a keyboard diagnostic disk if the system will boot up and determine if the problem is located to one key or to a group of keys

3. Check diagnostic for indication of keyboard failure which will indicate a faulty keyboard or interface

   a. Substitute a known good keyboard to see if it will solve the problem

   b. If the substitute keyboard doesn't solve the problem, check the keyboard interface which is a single-chip computer M1, Intel 8048

   c. Compare the M1 waveform with the Computerfacts waveform to verify M1 functions

   d. If M1 waveform is faulty, replace the M1 interface chip and check the system

   e. If the system still won't operate at this point, check the circuitry associated with the M1 chip which would include the Z1 sense amplifier

   f. If the system still won't operate, chances are the problem is not in the keyboard I/O, so move on to the next check point

JOB SHEET #2

4. Enter your findings in your troubleshooting log and discuss your findings with your instructor

F. Routine #5 — Checking tape I/O

1. Locate the components of the tape I/O so you'll know what you're working with
    a. The "data in" line goes to relay K1
    b. Relay K1 sends signals on to the 1741 op-amp
    c. The op-amp sends signals on to the PIA 8255 labeled U36
2. Place a tape on the cassette and play it to keep signals going into the data in line
3. Trace the audio signal through the K1 relay, the 1741 op-amp, and into the 8255 PIA

    (NOTE: When it comes out of the 8255, the signal becomes parallel data.)

    a. If the signal checks out all the way to the 8255 and tape I/O is still not working, substitute a known good 8255 and check the system again
    b. If the system will still not work, the problem is probably not with tape I/O, but somewhere in software or a bigger problem in the system, so move on to next check point
4. Check data output which comes from pin #12 on the 8255 through a logic gate used as an inverter at U63 and then goes out to the cassette
    a. If there is a complete loss of audio out, the problem is probably with the logic gate associated with the 8255
    b. Check the logic gate, and make another check of the 8255 if it has not been replaced because data out is almost totally software generated via the 8255
5. Check for the cassette not turning off and on by rechecking the K1 relay because cassette motor control is accomplished by switching the K1 relay
    a. If not okay, replace the K1 relay
    b. If K1 relay is okay, check the cassette itself for the problem
6. Enter your findings in your troubleshooting log and discuss your findings with your instructor
7. Check video or disk drive I/O by substituting new cards at the appropriate slots in the system bus

JOB SHEET #2

8. Enter your findings in your troubleshooting log and check off the routines that you have completed:

   ☐ Power supply voltages are verified
   ☐ Interrupts are verified
   ☐ Clock frequency is verified
   ☐ Bus activity is verified
   ☐ System ROM is verified
   ☐ System RAM is verified
   ☐ Keyboard and tape I/O are verified

9. Sign off your troubleshooting log

10. Discuss your findings with your instructor, and your instructor may direct you to complete any unchecked routines at another time or on another system

11. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TROUBLESHOOTING THE IBM® PC
UNIT IX

NAME ______________________

TEST

1. Complete the following statements concerning system characteristics of the IBM PC by inserting the word(s) that best completes each statement.

   a. The system is specifically designed to be expanded or modified to fulfill specific user needs and is not a ____________ ____________ system

   b. The system is a 16-bit data word system built around the Intel 8088 microprocessor, but since it uses 8-bit data in two-byte words, it is essentially a ____________ microprocessor that can use ____________ data words

   c. The case houses the main board and has peripheral slots for ____________ cards for user-selected peripheral I/O functions

   d. The power supply is housed in the system case and is adequate for driving ____________ ____________ ____________ and ____________ ____________ ____________ ____________

   e. Two spaces are provided inside the case for two standard height floppy disk drives or two half-height disk drives and ____________ ____________ ____________ ____________

2. Complete the following statements concerning component characteristics of the IBM PC by inserting the word(s) that best completes each statement.

   a. The system main board contains a minimum of 64K RAM which is permanently soldered to the board, but the board contains facilities for up to ____________ of 4164-type DRAM

   b. The main board may contain up to ____________ ROM

   c. The main board also contains a built-in interface for ____________ ____________ operations and a ____________ for ____________ generation

   d. The keyboard is provided with the basic system, but it is a separate device connected by a coil-wrapped cord so it can be used ____________ from the system

   e. System is sold with either a monochrome high resolution card or a color card and the user ____________ this option and the proper ____________ ____________ for it

   f. Floppy disk drives are normally ____________ ____________ ____________ ____________ and must also have a disk drive I/O card installed for proper operation

TEST

3. Complete the following list of materials for troubleshooting by inserting the word(s) that best completes each statement.

   a. When disk drives are purchased with the system, ____________ ____________ ____________ are included with the system

   b. If no disk drive is purchased with the system, ____________ ____________ diagnostics are included with the system

   c. An additional ____________ and ____________ ____________ complete with a diagnostic disk is available at the time of purchase for about $150 extra

   d. Other troubleshooting guidelines and very helpful schematics are available in ____________ CSCS2 COMPUTER: IBM® 5150

4. Solve the following problems concerning tips for troubleshooting the IBM PC.

   a. What should be checked before removing protective screws or rivets from the power supply on an IBM PC?

      Answer ____

      ____

   b. If troubleshooting indicates that repairs to the main board are going to run well over $200, what should be recommended to the customer?

      Answer ____

      ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

5. Demonstrate the ability to:

   a. Troubleshoot the power supply and operating voltages on an IBM® PC. (Job Sheet #1)

   b. Troubleshoot the main board on an IBM® PC. (Job Sheet #2)

TROUBLESHOOTING THE IBM® PC
UNIT IX

ANSWERS TO TEST

1. a. Self-contained
   b. 16-bit, 8-bit
   c. Five
   d. The system board, two floppy disk drives
   e. One hard disk drive

2. a. 256K
   b. 5
   c. Cassette tape, speaker, audio
   d. Remotely
   e. Selects, I/O card
   f. Part of the system

3. a. Disk-based diagnostics
   b. Tape-based
   c. Maintenance, repair manual
   d. Computerfacts

4. a. Check the warranty
   b. Make the repairs because a new board costs about $1000

5. Performance competencies evaluated according to procedures written in the job sheets

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the system and component characteristics of the Z-100 microcomputer. The student should also be able to troubleshoot a Z-100 power supply and the main board on a Z-100. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Differentiate between basic Z-100 configurations.
2. Complete statements concerning system characteristics of the Z-100.
3. Complete statements concerning component characteristics of the Z-100.
4. Solve problems concerning guidelines for troubleshooting the Z-100.
5. Demonstrate the ability to:
    a. Troubleshoot the power supply and operating voltages on a Zenith Z-100 microcomputer. (Job Sheet #1)
    b. Troubleshoot the main board on a Zenith Z-100 microcomputer. (Job Sheet #2)

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss unit and specific objectives

D. Discuss and demonstrate the procedures outlined in the job sheets.

E. At publication time, a Computerfacts™ for the Zenith Z-100 was not yet completed, but check with MAVCC at 1-800-654-3988 for information about this particular publication, and if you cannot find an OEM schematic, you should postpone the job sheets in this unit until a proper schematic is available.

F. Have a Zenith manufacturer's representative talk to the class about the Zenith Z-100 and other Zenith microcomputer systems, and ask the representative to stress troubleshooting problems that may be peculiar to Zenith products.

G. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

  1. Job Sheet #1 — Troubleshoot the Power Supply and Operating Voltages on a Zenith Z-100 Microcomputer

  2. Job Sheet #2 — Troubleshoot the Main Board on a Zenith Z-100 Microcomputer

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Z-100 User's Manual.* Saint Joseph, MI 49085: Zenith Data Systems, 1982.

B. *Component Data Catalog.* Santa Clara, CA 95051: Intel Corporation, 1981.

C. Stephenson, John, and Bob Cahill. *How to Maintain and Service Your Small Computer.* Indianapolis, IN 46268: Howard W. Sams & Co., Inc., 1983.

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

INFORMATION SHEET

I. **Basic Z-100 configurations**

   A. Self-contained — This Z-100 system has a CRT built into the case along with the video drive circuitry and the power supply for the CRT

   B. Low profile — This Z-100 system does not have the CRT built into the case, nor does it contain the power supply for the CRT

   (NOTE: The electrical configurations of the two systems are virtually identical, and although this unit of instruction deals with the low profile Z-100, the materials are, for the most part, adaptable to any troubleshooting or repair that might be required on the self-contained system.)

II. **System characteristics of the Z-100**

   A. The Z-100 is built around two microprocessors, the Intel 8085 and the Intel 8088, which can be used alternately to control the system

   B. The system is designed to run from a disk drive

      1. The Z-100 has no tape input facility

      2. The Z-100 will not boot up directly from ROM

   C. The internal power supply is a switching type that is capable of driving the main board, two floppy disk drives, and one hard disk drive

   D. The power supply is also capable of handling five auxiliary cards if its S-100 bus has that many cards added to it

   E. The system is capable of handling a total of 192K on board, but this capacity can be enhanced with additions to the S-100 bus

III. **Component characteristics of the Z-100**

   A. The keyboard is integrated and is interfaced to the main board with its own microcomputer

   B. The video system is more sophisticated than the average because of the memory mapped video scheme, and the video logic board requires special care in troubleshooting

   (NOTE: When a Z-100 is configured for RGB color, it requires an additional 192K of RAM on the main board.)

INFORMATION SHEET

C. The system output on the back of the system is capable of:

  1. Synchronous serial communications
  2. Asynchronous serial communications
  3. 8-bit parallel communications with handshaking
  4. Provisions for light pen operation
  5. A composite video signal, if the unit is self-contained

IV. **Guidelines for troubleshooting the Z-100**

A. Troubleshooting is best accomplished by using the disk-based diagnostics

B. When the system is totally inoperative, it will not only fail to read disk diagnostics, but because the system does not boot up from ROM it gives fewer clues about system problems than systems that do boot up through ROM

C. Signature analysis works well when the equipment is available, but the OEM does not provide signature tables, and SA can be used only if signatures are available from a time when the system was new and in excellent order

D. Because it is disk based, has dual processors, and bit-mapped graphics, the Z-100 is a challenging system to troubleshoot and requires attention and careful record keeping

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

JOB SHEET #1 — TROUBLESHOOT THE POWER SUPPLY AND OPERATING VOLTAGES ON A ZENITH Z-100 MICROCOMPUTER

A. Tools and equipment

1. Microcomputer as selected by instructor
2. Z-100 Technical Manual
3. DVOM
4. Dual-trace oscilloscope
5. Probe set
6. Basic hand tools
7. Pencil, paper, and troubleshooting log

B. Procedure

1. Unplug the system from the AC power source

   (NOTE: Remember to date and sign on your troubleshooting log, and save the log for use with Job Sheet #2.)

2. Pull the catches at the rear of the shell backward and lift the shell off and set it aside
3. Use a ¼" nutdriver to remove the two guide pins that hold the front panel assembly, and use a Phillips screwdriver to remove the remaining four screws
4. Lift up slightly on the front panel and remove the disk drive cable(s) and unplug the power supply cable
5. Set the front panel with the disk drive(s) aside in a safe place
6. Remove the two Phillips screws and the locator screws that hold the remainder of the cover in place
7. Remove the cover and lay it aside
8. Remove the three Phillips screws that hold the video logic board in place near the front of the case and lay it gently to one side with all cabling intact
9. Locate the power supply at the left rear corner of the case and the main board power supply connectors P1 and P2 (board labels are P101 and P102)

JOB SHEET #1

10. Note that the proper voltages are marked on the main board to indicate the proper voltage at each pin

11. Connect the black DVOM lead to ground on P1 (P101 on the board) and check for four readings of +5V

12. Move the black DVOM lead to ground on P2 (P102 on the board) and check for +16V, three +9V, and −16V (all clearly marked)

13. Move to connector P4 or P5 (the disc connectors), place the black DVOM on pin #3 or pin #4 and check for a reading of +12V on pin #1 and a reading of +5V on pin #4

    a. If voltages are okay, move on to the next check point

    b. If voltages are not okay, replace the power supply or follow your instructor's directions for removing power supply cover and troubleshooting the power supply itself

14. Make a check of voltages present on the system bus

    a. Check pin #1 for a reading of +8V

    b. Check pin #2 for a reading of +16V

    c. Pin #20 is ground

    d. Pin #50 is ground

    e. Check pin #51 for a reading of +8V

    f. Check pin #52 for a reading of −16V

    g. Pin #53 is ground

    h. Pin #70 is ground

    i. Pin #100 is ground

15. Enter your findings for voltages from the voltage supply, and also the voltages present on the system bus

    a. If voltages all validate, move on to the next check point

    b. If voltages are not okay, backtrace from the system bus to the power supply and correct as needed

16. Sign off your troubleshooting log

JOB SHEET #1

17. Have your instructor check your work and discuss your findings with your instructor

18. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

JOB SHEET #1

Troubleshooting and Repair Log

Customer's Name ______________________ Invoice ______________

Date ______________ Equipment and Serial # ______________________

Complaint ____

____

Technician's Name & ID #	Date	Time On	Time Off	Work Performed	Replacement Parts Used & Inventory #

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

JOB SHEET #2 — TROUBLESHOOT THE MAIN BOARD ON A ZENITH Z-100 MICROCOMPUTER

A. Tools and equipment

1. Microcomputer as selected by instructor
2. Z-100 Technical Manual
3. DVOM
4. Dual-trace oscilloscope
5. Probe set
6. Basic hand tools
7. Pencil, paper, and troubleshooting log

B. Routine #1 — Checking the 8085 and 8088 microprocessors

1. Unplug the system and remove the case as previously outlined

   (NOTE: Remember to date and sign on your troubleshooting log from Job Sheet #1.)

2. Unplug the two ribbon connectors to the video logic board, turn it over and then unplug the power supply cable and the composite video cables from the video logic board

3. Lay the video logic board safely aside

4. Plug system into AC power source and turn the microcomputer ON

   (**CAUTION:** From this point on in this routine, you're exposed to potentially dangerous voltages, so work with care.)

5. Check the 8085 supply voltages with the following procedure:

   a. Place the black DVOM ground lead on pin #20 (or on a common)

   b. Place the red DVOM lead on pin #40 and check for +5V

6. Check the 8088 supply voltages with the following procedure:

   a. Place the black DVOM ground lead on pin #1 or pin #20

JOB SHEET #2

   b. Place the red DVOM lead on pin #40 and check for +5V

   c. If any voltages are not okay, backtrace to the power supply because those voltages have already been validated

7. Check the clocks on the 8085 and 8088 with the following procedures:

   a. On the 8085, check pin #37 for a 5 MHz signal

   b. On the 8088, the clock signal comes from the external clock generator, U236, and should give a reading of 5 MHz on pin #19

   c. If the clocks are okay, move on to the next check point

   d. If the 8085 clock is not okay, replace the crystal, and if that doesn't correct the problem, replace the 8085

   e. If the 8088 clock is not okay, replace the 15 MHz crystal, and if that doesn't correct the problem, replace the U236 clock generator (Intel 8284)

8. Check the following 8085 interrupts:

   a. Check the INTR at pin #10 to make sure it's at logic high (above 2.4V)

   b. Check the TRAP at pin #6 to make sure it's at logic high (above 2.4V)

   c. Check the INTA at pin #11 to make sure it's at logic high (above 2.4V)

   d. Check the RESET at pin #36 to make sure it's at logic high (above 2.4V)

9. Check the following 8085 interrupts which are not used but are connected to ground:

   a. RST 5.5 should show 0V

   b. RST 6.5 should show 0V

   c. RST 7.5 should show 0V

10. Check the following 8085 control lines:

   a. Check READY at pin #35 to make sure it's at logic high (above 2.4V)

   b. Check HOLD at pin #39 to make sure it's at logic high

   (NOTE: Remember, control pins at logic low will also stop the microprocessor.)

   c. If interrupts and control lines are okay, move on to next check point

JOB SHEET #2

   d. If interrupts or controls are not okay, backtrace through the logic to the lines to isolate the problem(s)

11. Check the following 8088 interrupts:
    a. Check the RESET at pin #21 to make sure it is at logic low
    b. Check the INTR at pin #18 to make sure it is at logic low
    c. Check the INTA at pin #24 to make sure it is at logic high
    d. Check the NMI at pin #17 to make sure it is at logic low

12. Check the following 8088 control lines:
    a. Check HOLD at pin #31 to make sure it is at logic low
    b. Check HLDA at pin #30 to make sure it is at logic low
    c. Check READY at pin #22 to make sure it is at logic high
    d. If interrupts and control lines are okay, move on to next check point
    e. If interrupts or control lines are not okay, backtrace through the logic to the lines to isolate the problem

13. Check activity on the address and data bus lines with the following procedure:
    a. On the 8085, the address bus activity should show up on pins #12 through #19 (these are multiplexed and are both address and data lines)
    b. On the 8085, the address bus activity should also show up on pins #21 through pin #28 (these are only address lines)
    c. On the 8088, the address bus activity on the multiplex lines should show up on pins #9 through pin #16
    d. On the 8088, the straight address line activity should show up on pins #2 through pin #8, and pins #35 through pin #39 (remember, the 8088 has 20 address lines)

14. Enter your findings in your troubleshooting log and discuss your findings with your instructor

15. Move to the next check point if the system is not operating at this point, but reevaluate your procedure and findings and check the following when you are relatively sure:

    ☐ Power supply voltages are verified

    ☐ Interrupts and controls lines are verified

    ☐ Clock frequency and bus activity are verified

JOB SHEET #2

C. Route #2 — Checking system ROM and PROM

1. Run the diagnostic software, if it is available, because it will examine ROM and isolate specific ROM problems, but if diagnostics are not available, continue with troubleshooting

2. Check first with the DVOM for proper voltages on the ROM:

   a. Place the DVOM ground lead on pin #14 of the ROM at board location U190

   b. Place the DVOM positive lead on pin #28 and check for a reading of +5V and also check pin #1 for a reading of ±5V

3. Check next with the DVOM for proper voltages on the following PROMs:

   a. Place the DVOM ground lead on pin #8 of the PROM at board location U179, the PROM at U111, and then the PROM at U226

   b. Place the DVOM positive lead on pin #16 and check for a reading of +5V on each of the three PROMs

   c. If ROM and PROM voltage readings are okay, move on to the next check point

   d. If ROM and PROM voltage readings are not okay, backtrace to the voltage supply and correct any problems

   e. If the system will still not work, substitute ROM first, check the system, then substitute PROM and check the system

4. Enter your findings in your troubleshooting log and discuss your findings with your instructor

5. Move on to the next check point if the system is still not operating, but reevaluate your procedure and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are validated

   ☐ Interrupts and control lines are verified

   ☐ Clock frequency and bus activity are verified

   ☐ System ROM and PROM are verified

D. Routine #3 — Checking system RAM

1. Run the diagnostic software, if it is available, because it will examine RAM and isolate specific RAM problems, but if diagnostics are not available, continue with troubleshooting

JOB SHEET #2

2. Check first with the DVOM for proper voltages on DRAMs:

   a. Locate the three banks of RAM chips, bank one at U101 through U109, bank two at U117 through U125, and bank three at U137 through U145

   b. Place the DVOM ground lead on pin #8 and the positive lead on pin #16 and check for a reading of +5V

   c. Repeat the voltage check for each chip in each bank of RAM

   (NOTE: Take the time to make this chip by chip RAM voltage check because no matter how much time it takes to do it, it will eventually save further troubleshooting time, and remember too that the ninth chip in each RAM bank is a parity checking chip.)

   d. If RAM voltages are okay, move on to the next check point

   e. If RAM voltages are not okay, backtrace to the power supply and correct any problems

   f. If the system will still not operate, substitute bank one RAM with known good RAMs and check the system

   g. If the system will still not operate, take the RAM chips from bank one and substitute them in the second bank, and check the system

   h. Repeat the substitution procedure for the third bank

   (NOTE: This is a good point to check the decoders associated with RAM.)

3. Enter your findings in your troubleshooting log and discuss your findings with your instructor

4. Move on to the next check point if the system is still not operating, but reevaluate your procedure and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are verified

   ☐ Interrupts and control lines are verified

   ☐ Clock frequency and bus activity are verified

   ☐ System ROM and PROM are verified

   ☐ System RAM is verified

E. Routine #4 — Checking keyboard I/O

1. Determine which I/O device is probably at fault and start troubleshooting at that part of the system (this routine assumes keyboard problems)

JOB SHEET #2

2. Locate the keyboard encoder which is an Intel 8048 single-chip microcomputer at board location U204

3. Locate the port labeled P107 and the buffer decoders at U199 and U184, and port labeled P105

4. Substitute a known good keyboard

   a. If the keyboard is okay, check the decoders

   b. If the keyboard is not okay, replace the old keyboard and look elsewhere for the trouble

5. Locate the 74LS156 decoders at U199 and U184 and substitute known good decoders for both of them

   a. If the system works, move on to next check point

   b. If the system still doesn't work, go to each of the lines on P107

6. Check P107 at pins #1 through pin #10, except pin #2, for readings of +5V

   a. If the readings are okay, move on to next check point

   b. If the readings are not okay, check the pull-up resistors RP119 and RP126

   c. If the resistors are okay, then substitute a known good 8048 single-chip computer at U204

7. Enter your findings in your troubleshooting log and discuss your findings with your instructor

8. Continue with I/O troubleshooting if the system is still not operating properly

F. Routine #5 — Checking audio output

1. Determine which I/O device is probably at fault and start troubleshooting at that part of the system (this routine assumes that the audio beep and/or the audio click are not working)

2. Check first for the presence of either a beep or a click

   a. If there is a beep and no click or a click and no beep, then replace the U218 switch

      (NOTE: This switch at U218 switches the 555 timer so that it signals direct to the Darlington amp for a key click or goes through the oscillator to create a beep.)

JOB SHEET #2

- b. If there is still a problem, check the circuitry associated with the audio output
- c. If circuitry is okay, locate the ceramic X101 transducer and replace it
- d. If the problem is still present, check the 555 timer and the Darlington amp and replace as needed

3. Enter your findings in your troubleshooting log and discuss your findings with your instructor

4. Continue with I/O troubleshooting if the system is still not operating properly

G. Routine #6 — Checking I/O ports from the system

1. Determine which I/O device is probably at fault and start troubleshooting at that part of the system (this routine assumes problems with system I/O ports)

2. Locate the two serial ports J1 and J2
    - a. J2 is a DTE serial port that is synchronous for use with a MODEM
    - b. J1 is a DCE serial port that is asynchronous for use with a printer
    - c. Both the J2 and J1 ports use a Motorola 68661 EPCI (enhanced programmable communications interface) chip

3. Check J2 if there is a MODEM problem
    - a. The J2 port is pretty much self-contained except for an IC buffer between the EPCI and the physical port connectors, so substitute a known good IC buffer
    - b. If there is still a problem, substitute a known good EPCI and retest the system

4. Repeat the previous procedure for the J1 port if it is required

5. Continue I/O checks as needed for the parallel port located at the J3 connector
    - a. The port has a single chip octal buffer driver that works with a Motorola 6821 PIA (peripheral interface adapter)
    - b. The PIA has an A and a B port, and the eight data lines for parallel use come from the A and B ports through the octal buffer to the system parallel port

JOB SHEET #2

   c. Locate the resistor package RP103 and check it, because when the port is not attached to an external device, four of the five lines at RP103 should be at logic high

      (NOTE: There are five control lines that originate at ports A and B of PIA, and the RP103 should pull four of these lines up to 5V when the port has no external connection.)

   d. Replace the RP103 if needed and check the system

   e. If there is still a problem, check and replace the octal buffer and then, if needed, check and replace the PIA

6. Enter your findings in your troubleshooting log and discuss your findings with your instructor

7. Continue with I/O troubleshooting if the system is still not operating properly

H. Routine #7 — Checking the video logic board

1. Determine which I/O device is probably at fault and start troubleshooting at that part of the system (this routine assumes on-board video problems)

2. Locate the fuseable ROMs U369, U370, and U371 because these ROMs are the link between the address and data lines going into the microprocessor and into the video logic board

   (NOTE: There is one 20-pin ROM and two 16-pin ROMs and can be easily spotted because of their location where the interface cable enters the video logic board and the white labels that identify them.)

3. Use a logic probe or a scope to check for activity on the incoming bus, and if there is activity there, there should also be activity from the ROMs

   a. If signals are present on the microprocessor bus and other features such as video RAM and CRT controller appear to be working, check video select options

   b. If video select options aren't working, replace the three fuseable ROMs because if any one of these is not working, it would likely prevent operation of the video system

4. Check video memory by first checking the supply voltages on the RAM chips which are standard 4164-type DRAM

   a. Place the DVOM ground lead on pin #8^{VSS} and the positive lead on pin #16

   b. Check each RAM for a reading of +5V

JOB SHEET #2

   c. Substitute RAM a bank at a time and test system after each bank has been substituted

      (NOTE: If you're working with a system that has a monochrome display, only the middle RAM bank will have RAM in place; the other two RAM banks are used strictly for color.)

   d. If there still seems to be a RAM problem, check to see if the crystal clock frequency is being generated at the output of U344, pin #11

   e. If the U344 output is okay, check the flip/flop dividers U343, U336, and U367 and then follow the clock signal down and check it at the U376 decoder where the RAS and CAS signals are generated

   f. If you suspect a video timing problem, check all the associated circuitry of the flip/flops and decoders

   g. If you suspect a problem with the timing for the video system memory, the problem is related to the main board microprocessor

   h. Check the arbitration logic in parts U378 and U361

5. Check the CRT controller if the video problem is a lack of vertical or horizontal sync

   a. This is part 6845 or #U330 and controls the relationship between character generation and the CRT

   b. The 6845 also controls the sync signal so check it carefully with a scope or DVOM

      (NOTE: Do not confuse the CRT controller with the video logic board circuit that generates the signals associated with the CRT.)

6. Enter your findings in your troubleshooting log and check off the routines that you have completed

   ☐ Power supply voltages are verified
   ☐ Interrupts and control lines are verified
   ☐ Clock frequency and bus activity are verified
   ☐ System ROM and PROM are verified
   ☐ System RAM is verified
   ☐ Keyboard I/O is verified
   ☐ Audio output is verified
   ☐ I/O ports from system are verified
   ☐ Video logic board is verified

JOB SHEET #2

7. Sign off your troubleshooting log

8. Discuss your findings with your instructor, and your instructor may ask you to complete any unchecked routines at another time or on another system

9. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

NAME ________________________

TEST

1. Differentiate between basic Z-100 configurations by placing an "X" beside the definition of a low profile system.

   _____a. This Z-100 system has a CRT built into the case along with the video drive circuitry and the power supply for the CRT

   _____b. This Z-100 system does not have the CRT built into the case, nor does it contain the power supply for the CRT

2. Complete the following statements concerning system characteristics of the Z-100 by inserting the word(s) or figure(s) that best completes each statement.

   a. The Z-100 is built around two microprocessors, the Intel _____________ and the Intel _____________, which can be used alternately to control the system

   b. The system is designed to run from a disk drive

      1) The Z-100 has no _____________ _____________ facility

      2) The Z-100 will _____________ _____________ _____________ _____________ from ROM

   c. The internal power supply is a _____________ type that is capable of driving the main board, two floppy disk drives, and one hard disk drive

   d. The power supply is also capable of handling _____________ auxiliary cards if its S-100 bus has that many cards added to it

   e. The system is capable of handling a total of _____________ on board, but this capacity can be enhanced with additions to the S-100 bus

3. Complete the following statements concerning component characteristics of the Z-100 by inserting the word(s) that best completes each statement.

   a. The keyboard is integrated and is interfaced to the main board with its own _____________

   b. The video system is _____________ _____________ than the average because of the memory mapped video scheme, and the video logic board requires special care in troubleshooting

TEST

c. The system output on the back of the system is capable of:

   1) Synchronous ____________ communications

   2) Asynchronous ____________ communications

   3) 8-bit ____________ communications with handshaking

   4) Provisions for ____________ ____________ operation

   5) A ____________ video signal, if the unit is self-contained

4. Solve the following problems concerning guidelines for troubleshooting the Z-100.

   a. When a Z-100 is totally inoperative, why is it perhaps a bit harder to troubleshoot than some other systems?

      Answer ____

      ____

   b. What makes the video section of a Z-100 more difficult to troubleshoot?

      Answer ____

      ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

5. Demonstrate the ability to:

   a. Troubleshoot the power supply and operating voltages on a Zenith Z-100 microcomputer. (Job Sheet #1)

   b. Troubleshoot the main board on a Zenith Z-100 microcomputer. (Job Sheet #2)

TROUBLESHOOTING THE ZENITH Z-100 MICROCOMPUTER
UNIT X

ANSWERS TO TEST

1. b

2. a. 8085, 8088
   b. 1) No tape input
      2) Not boot up directly
   c. Switching
   d. Five
   e. 192K

3. a. Microcomputer
   b. More sophisticated
   c. 1) Serial
      2) Serial
      3) Parallel
      4) Light pen
      5) Composite

4. a. It does not boot up from the kernel ROM
   b. The video logic board and the bit-mapped graphics

5. Performance competencies evaluated according to procedures written in the job sheets

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the system and component characteristics of the Model III microcomputer. The student should also be able to troubleshoot a Model III power supply and the main board on a Model III. These competencies will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to troubleshooting the TRS-80® Model III microcomputer with their correct definitions
2. Complete statements concerning system characteristics of the Model III.
3. Complete statements concerning component characteristics of the Model III.
4. Solve problems concerning troubleshooting guidelines for the Model III.
5. Demonstrate the ability to:
    a. Disassemble a TRS-80® Model III microcomputer. (Job Sheet #1)
    b. Troubleshoot the power supply on a TRS-80® Model III microcomputer. (Job Sheet #2)
    c. Troubleshoot the main board on a TRS-80® Model III microcomputer. (Job Sheet #3)

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

SUGGESTED ACTIVITIES

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Discuss unit and specific objectives.

D. Discuss information sheet.

E. Discuss and demonstrate the procedures outlined in the job sheets.

F. Have a Model III disassembled to the point where you can clearly demonstrate the critical clearance in removing and replacing the CRT, and impress upon students that careless handling of the CRT can be a costly matter.

G. Review procedures for troubleshooting video systems because this is the first integrated video system that many students will confront, and students with limited video experience may require additional assistance.

H. The *TRS-80® Technical Reference Manual* as well as *Computerfacts™ CSCS-5* should both be referenced for the job sheets in this unit. This is one case where the manufacturer's technical information is available and contains excellent schematics and other references.

I. Give test.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Information sheet

C. Job sheets

   1. Job Sheet #1 — Disassemble a TRS-80® Model III Microcomputer

   2. Job Sheet #2 — Troubleshoot the Power Supply on a TRS-80® Model III Microcomputer

   3. Job Sheet #3 — Troubleshoot the Main Board on a TRS-80® Model III Microcomputer

D. Test

E. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *SAMS Computerfacts™ CSCS-4 Computer: TRS-80® III.* Indianapolis, IN 46206: Howard W. Sams & Co., 1985.

B. *TRS-80® Model III Technical Reference Manual for Programmers and Technicians.* Fort Worth, TX 76102: Tandy Corporation, 1981.

C. *Disk System Owner's Manual.* Fort Worth, TX 76102: Tandy Corporation, 1980.

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

INFORMATION SHEET

I. **Terms and definitions**

   A. Backtracing — Using a current tracer to check for breaks in supply traces between power supplies and other components

   B. CAS — Column address select

   C. D RAM — Dynamic ram

   D. RAS — Row address select

II. **System characteristics of the Model III**

   A. The system is built around a Z-80 microprocessor

   B. Depending on the version, it may have as low as 4K of ROM or as high as 14K of ROM

   C. Depending on the version, RAM may be as low as 4K or as high as 48K

   (NOTE: The Model III cannot be expanded to 64K.)

   D. Has a real time clock on board

   E. May have one or two 5 1/4" single-sided, double-density disk drives

   F. Has a self-contained video system

   G. May have an optional RS-232C serial port so that a serial printer or a modem can be interfaced with the system

III. **Component characteristics of the Model III**

   A. Has a standard 65-key ASCII keyboard that may or may not contain a numeric keypad

   B. Keyboard is case mounted, but is cabled to the main board

   C. Drive circuitry for video is on a separate PC card which is housed along with the CRT in the upper case

   D. Power supply is on a separate card with the power cable and power switch attached so that the power supply is not on the main board

   E. The floppy disk controller is also on a separate board that runs behind and parallel to the main board

   F. Has a cassette interface

INFORMATION SHEET

IV. **Guidelines for troubleshooting the Model III**

A. Has an aluminum shield at the back of the chassis that must be removed to access the main board

B. Is not a bus oriented system so general troubleshooting cannot be accomplished on the system bus

C. Since the video system is integrated, video troubleshooting is different from systems where the video is not integrated

D. There are dangerous high voltages around the video section, and especially the CRT, and working around the video sections requires extra care

E. Some of the high voltages around the video system should be checked only with a high voltage oscilloscope probe

F. Always be careful when removing or replacing the CRT on a Model III because it is so configured that it is very easy to damage

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

JOB SHEET #1 — DISASSEMBLE A TRS-80® MODEL III MICROCOMPUTER

A. Tools and equipment

1. Phillips and flatblade screwdrivers
2. Container to hold screws
3. Pencil and paper

B. Procedure

1. Unplug microcomputer from power source and remove all peripherals from the microcomputer

   (NOTE: Remember to sign on your troubleshooting log which accompanies this job sheet, and be sure to save the log for use with the other job sheets in this unit.)

2. Check workbench for anti-static control (static mat is preferred), and clean surfaces so case will not be damaged
3. Turn the unit on its side or its back
4. Have pencil and paper ready to note the locations of different types of screws as they are removed because it's important that they go back where they came from

   (NOTE: With experience, technicians learn this step by heart, but beginners should make notes until they develop that special sense of remembering where things came from.)

5. Leave the screw at the top of the case in place, but remove the other nine screws that hold the case to the chassis

   (NOTE: Leaving the 10th screw in place will keep the microcomputer from falling out of the case while it's lying on its side.)

6. Tip the microcomputer back to where it is resting in a nearly normal position and then remove the final screw
7. Set the microcomputer on its base and remove the one small metal screw with the flat washer on the back panel
8. Place all the screws in a container so they won't get lost, or leave them in a safe place arranged in order for replacement

JOB SHEET #1

9. Place a worklight or benchlight in such a position that it will light the interior components and especially the CRT

    (**CAUTION:** Follow the next steps carefully because they are the most important steps in the procedure and could result in costly damage to the system if not done properly.)

10. Look through the air vent grille on top of the case, locate the end of the CRT where the connection is, and note how it projects slightly underneath a metal casting

11. Lift slowly while keeping your eyes on the CRT and gently move the case up and slightly backward at the same time so the connector end of the CRT will safely clear the metal casting

12. Lift gently until the CRT is above the chassis, then swing the case to the left and lay it on its side while being careful not to pull the CRT cables loose in the process

13. Note that the cables plug into the video system which carry both the video signal and the power source through a pin connector on the printed circuit board, and unplug this video connector

14. Place the cover safely aside

15. Remove the four screws that hold the combination back cover/RF shield that protects the mother board

16. Place the four screws in a container and save them for reassembly

17. Have your instructor check your work

18. Reassemble and replace the outer case by reversing the procedure outlined for disassembly, taking special care with the CRT as previously noted

    (NOTE: Remember to sign off your troubleshooting log at the appropriate time.)

19. Clean up area and return tools and equipment to proper storage or prepare for next job sheet as directed by your instructor

    (NOTE: Your instructor may direct that reassembly be delayed until the power supply and other accessible components have been checked.)

JOB SHEET #1

Troubleshooting and Repair Log

Customer's Name ______________________________ Invoice __________________

Date ____________________ Equipment and Serial # ________________________

Complaint ____

____

Technician's Name & ID #	Date	Time On	Time Off	Work Performed	Replacement Parts Used & Inventory #

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

JOB SHEET #2 — TROUBLESHOOT THE POWER SUPPLY ON A TRS-80® MODEL III MICROCOMPUTER

A. Tools and equipment

1. Microcomputer as selected by instructor
2. DVOM or VOM
3. Pencil and paper
4. Troubleshooting log

B. Procedure

1. Sign on your troubleshooting log, then unplug the microcomputer and disassemble as outlined in Job Sheet #1

   (**CAUTION:** This is a switching power supply and if it is disconnected from its load, it will not give proper readings and may even damage the power supply.)

2. Make a note on your troubleshooting log to remind you that the three voltages you are checking for are:

   a. +5V

   b. +12V

   c. -12V

3. Connect the DVOM and make range settings for the 12V voltages to be measured

   (**CAUTION:** Be very careful from this point on because after the microcomputer is plugged in again you will be exposed to potentially dangerous high voltages.)

4. Plug the microcomputer into an AC power source

5. Locate the power supply mounted on the back side of the support panel that holds the main PC board, and the power supply outlets on the left hand side of the board

   (NOTE: All the power supply outlets may not be hooked up, but the one to the main PC board will be.)

6. Follow the power supply leads to the main board, locate the power supply connector there, and note the yellow, black, and red leads going into the connector

JOB SHEET #2

7. Place the black ground lead from the DVOM onto the black lead into the connector and keep it there for all of the voltage checks that follow

   (NOTE: There are small slots in the face of the connector to provide easy access for measuring all voltages and for reaching the ground.)

8. Place the red positive lead from the DVOM onto the slot below the entry point of the red lead into the connector and check for a reading of +5V, approximately

9. Place the red positive lead from the DVOM onto the slot below the entry point of the orange lead into the connector and check for a reading of +12V, approximately

   (NOTE If you're working with a meter that does not have automatic polarity, reverse the black and red meter leads for the next measurement.)

10. Place the red positive lead from the DVOM onto the slot below the entry point of the yellow lead into the connector and check for a reading of -12V

11. Make a record of all three readings and carefully note any plus or minus variations that are excessive

    a. If any voltage readings are improper, double check all measurements

    b. If voltage readings are still improper after a careful second evaluation, replace the power supply (or rebuild and replace the power supply)

    c. If all voltage readings are proper, move on to check the core system, CPU, clock functions, ROM, and RAM

12. Have your instructor check your work

13. Reassemble the microcomputer, clean up area and return tools to proper storage, or delay reassembly and prepare for next job sheet as directed by your instructor

14. Sign off your troubleshooting log at the appropriate time

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

JOB SHEET #3 — TROUBLESHOOT THE MAIN BOARD ON A TRS-80® MODEL III MICROCOMPUTER

A. Tools and equipment

1. DVOM or VOM
2. Dual-trace oscilloscope
3. Frequency meter (if available)
4. Microcomputer as selected by instructor
5. Service manual and/or Computerfacts®

B. Routine #1 — Checking the kernel system

1. Sign on your troubleshooting log, then remove the microcomputer case and check power supply voltages as outlined in previous job sheets

2. Make a random check at some of the power supply pins in the IC circuits to make sure proper voltage is being carried to all the circuitry

   (CAUTION: Work with care because you will be exposed to potentially hazardous voltages throughout most of this procedure.)

3. Place a 40-pin microprocessor test clip over the Z-80 pins (look for U77 on the board)

4. Set the DVOM for DC voltage and a range that will test for +5V

5. Check for +5V on pin #11 by placing the red lead of the DVOM on pin #11 and the black ground lead on GND at pin #29

   a. If +5V is present, this will indicate that the proper voltage is available to the Z-80 and you may move on to the next check point

   b. If +5V is not present, then backtrace supply lines for problems because proper voltages have already been verified at the power supply

   c. Backtrace with the DVOM or use the logic probe to check all points along the trace, and keep this up until you find the break indicated by logic 1

   d. Also check the Z-80 socket to assure that the problem is not electromechanical because that's where many parts are prone to failure

JOB SHEET #3

6. Check the interrupts and other control pins while the DVOM ground lead is still connected to pin #29

7. Check the INT at pin #16 for +5V, although it may be anywhere between +2.4V and +5V

8. Check the NMI at pin #17 for between +2.4V and +5V

9. Check the RESET at pin #26 for between +2.4V and +5V

   (NOTE: This interrupt circuit has a built-in delay to permit the microprocessor to run through its warmup cycle, but at this point, the system should be warmed up, and readings should be within the boundaries stated.)

10. Check the BUS REQUEST at pin #25 for nearly +5V

    (NOTE: This pin is not in use, so it's permanently tied up at about +5V.)

11. Check the WAIT at pin #24 for between +2.4V and +5V

    a. If all the preceding interrupts and control pins are at logic 1, then move on to the next check point (any reading over 2.4V indicates logic 1)

    b. If interrupt and control pins are not at logic 1, then check the support circuitry that supplies the signal to the specific pin(s) that is faulty

    c. If the RESET at pin #26 is not at logic 1, check the three logic gates associated with the RESET function

12. Check out interrupt and controls pins, then test the microcomputer, and if it still does not operate properly, the next logical step is to check the clock frequency

13. Plug in and turn on the dual-trace oscilloscope

14. Connect one of the two oscilloscope probes to pin #6 and observe the high frequency waveform, and remember that only one probe is required to check the clock

    (NOTE: An alternate method to obtain a quick check here is to use a frequency meter with a probe on pin #6 and the ground probe on pin #29 because this should give an exact reading of 2.02752 MHz, and the reading is actually more precise than you can get with an oscilloscope.)

15. Verify a frequency reading of near 2MHz

    a. If a reading of about 2MHz is present, move on to the next check point

    b. If the waveform and reading are not correct, check the clock generator for production of about 10 MHz (10.1376 MHz)

    c. If the clock generator is okay, then check the frequency divider circuits with the scope or a frequency meter and correct as needed

JOB SHEET #3

16. Test the microcomputer for proper operation, and if the system is working right again, there is no need for further troubleshooting

17. Enter your findings in your troubleshooting log and discuss your findings with your instructor

18. Verify that the microcomputer will still not operate before substituting a known good Z-80 microprocessor, and then if the system will still not operate, move on to the next logical check point which means checking the system ROM's

    (NOTE: It may seem that the Z-80 should be replaced as a very first step, but if the problem were in the circuitry around the Z-80, the problem would still not be isolated and the new Z-80 would be ruined.)

19. Reevaluate your procedures and findings and check the following when you are relatively sure:

    ☐ Power supply voltages are verified

    ☐ Interrupts and control lines are verified

    ☐ Clock and timing are verified

C. Routine #2 — Checking system ROM

1. Turn microcomputer ON and work with caution throughout this routine because you'll be exposed to potentially hazardous voltages most of the time

2. Find the location of the A, B, and C ROM's on the main board and set the DVOM

3. Check the A ROM for +5V at pin #24 while ground is on pin #12

4. Check the B ROM for +5V at pins #24 and #21 while ground is on pin #12

5. Check the C ROM for +5V at pin #21 while ground is on pin #18

    a. If supply voltages are correct, there's only a slim chance of faulty ROM's, but turn the power OFF and substitute a known good set of ROM's

    b. If the system operates properly after turning the power back ON, then go back and replace the new ROM's one at a time with the original ROM's and test the system to find the one or the two bad ROM's (it will not be all three)

    c. If supply voltages are incorrect, then trace supply voltages back to the power supply with the DVOM, the scope, or a logic probe

6. Complete voltage checks and then turn the computer OFF

JOB SHEET #3

7. Lay the top cover of the microcomputer, including the monitor, alongside the microcomputer on its left side and connect the cable from the main board to the video board

   (NOTE: This connection can be made only one way because it has a reversing pin to prevent a connection error.)

8. Turn the microcomputer ON and test ROM's with troubleshooting software and monitor display, and if problem is corrected, there is no need for further troubleshooting

9. Enter your findings in your troubleshooting log and discuss your findings with your instructor

10. Verify that the microcomputer will still not operate before moving on to the next logical check point which means checking the system RAM's

11. Reevaluate your procedures and findings and check the following when you are relative sure:

   ☐ Power supply voltages are verified

   ☐ Interrupts and control lines are verified

   ☐ Clock and timing are verified

   ☐ System ROM is verified

D. Routine #3 — Checking system RAM

1. Locate the three rows of RAM chips in the upper right corner looking from the back of the machine

2. Set the DVOM, turn the microcomputer ON, and check each RAM chip for the following voltages with pin #16 as ground:

   a. Pin #1 should be -5V

   b. Pin #9 should be +5V (change leads if meter does not have automatic polarity)

   c. Pin #8 should be +12V

   (NOTE: It may seem troublesome to check voltages on every RAM chip, but it pays to take the time to do it, and the process can be accomplished quickly if you use the DVOM, leave the ground on pin #16, then quickly probe all the -5V's on all chips first, then all the +5V's on all chips, and finally, the +12V's because no matter which chip you're checking, the ground can stay on the first pin #16.)

JOB SHEET #3

3. Enter your readings in your troubleshooting log and discuss your findings with your instructor
    a. If voltages are correct on all RAM's, move on to the next check point
    b. If any voltages are missing on any of the chips, backtrace to the power supply

        (NOTE: Remember that the power supply does not supply a -5V, but it does supply -12V, so there is a -5V regulator labeled VR1 that changes the -12V to -5V, and if -12V is present at the power supply, then the problem may be with the VR1.)

4. Continue the system RAM check by turning the microcomputer OFF and substituting an entire bank of RAM one at a time according to the following procedure:
    a. Start with the first RAM bank, chips U7 through U14
    b. Remove the chips with a chip puller and place the chips in order on a piece of static foam

        (NOTE: It is essential to keep the chips in order so that if there is a problem you won't be moving it around.)

    c. Place new RAM in the first bank, turn the microcomputer ON, and check the system
    d. If the problem is still there, turn the microcomputer OFF and remove the second bank of RAM, U25 through U32
    e. Replace the second bank of RAM not with new RAM chips, but with the chips taken from the first bank in the same order in the second bank as they were in the first bank
    f. Keep bank two chips in order on the static foam as they are removed with the chip puller
    g. Turn the microcomputer ON, test the system, and if the problem is still present, pull the third bank of RAM chips, replace them with the RAM chips taken from the second bank, and test the system again
    h. Check all of RAM in this fashion and if there is no problem, put the chips taken from the third bank back in the first bank after removing the known good RAM's so they can be used again

5. Make a final RAM evaluation according to the following procedure:
    a. If you suspect a data problem, replace chip #U63, check the system, then replace chip #U64 and check the system, if needed

JOB SHEET #3

b. If you suspect an addressing problem, replace chip #U91, check the system, then replace chip #U92 and check the system, if needed

(NOTE: If you have the equipment available, signature analysis is an alternate and extremely effective method for checking system RAM.)

6. Enter your readings in your troubleshooting log and discuss your findings with your instructor

7. Verify I/O problems before starting the next routine

8. Reevaluate your procedures and findings and check the following when you are relatively sure:

   ☐ Power supply voltages are verified

   ☐ Interrupts and control lines are verified

   ☐ Clock and timing are verified

   ☐ System ROM is verified

   ☐ System RAM is verified

E. Routine #4 — Checking keyboard I/O

1. Determine which I/O device is probably at fault and start with that part of the system (this routine assumes keyboard problems)

2. Check the keyboard through the video display first, if the machine will boot up, to determine if the problem is isolated to one or a few keys

3. Check next for mechanical problems because on this system the individual keys can be disassembled and cleaned with the following procedure:

   a. Remove the keyboard cover to expose everything on the underside of the keyboard

   b. Key covers snap off with little effort so that contact points can be sprayed with cleaner

   c. If a need for more thorough cleaning is evident, take the lower board cover off to expose the rest of the key mechanisms and clean as needed

4. Check the keyboard buffer chips #U51, #U65, #U34, and #U35 with a logic probe to verify the logic levels specified in the service manual or Computerfacts

   a. If any buffer chips need to be replaced, the board will have to be removed from the system because these chips are soldered, not socketed, and will have to be desoldered

JOB SHEET #3

   b. If buffer chips are okay, and since keyboard encoding takes place in the major ROM which has already been checked, keyboarding should be okay

   c. If there is, however, still a problem, check the logic at chip #U60 because if there is a problem here there would be no strobe from the addressing system for the keyboard

5. Enter your readings in your troubleshooting log and discuss your findings with your instructor

6. Verify tape I/O problems before starting the next routine

F. Routine #5 — Checking tape I/O

1. Locate the cassette input jack at the back of the microcomputer and then follow the cable to the left hand side of the board where the cassette input goes to the 8-pin U79 chip

   (NOTE: The U79 chip number is not silk-screened onto the board, so you can track it through the cable connection or look for U80 which is labeled, and the U79 is just to the left and adjacent to input capacitor C85.)

2. Refer to Computerfacts for the proper audio range of the U79 chip and check it with an oscilloscope

   (NOTE: This is not an audio signal for listening quality, but simply an audio signal from the cassette tape.)

   a. If the audio range is not okay, replace the U79 chip

   b. If the audio range is okay, check the relay motor

3. Enter the keyboard commands necessary to turn the relay motor on and off

   a. If the commands function, move on to the next check point

   b. If the commands will not start and stop the cassette tape, check the read relay K1 and replace if necessary

   c. Also check the CR7 protective diode for the relay with a DVOM to make sure it has proper forward to back resistance, and replace if necessary

   d. Other parts of the circuitry, the U80 and U96 chips should be checked for proper waveforms with the cassette activated and replaced as necessary

4. Use an oscilloscope to check for the proper waveform at the output side of the tape I/O at U78 and replace as necessary

   (NOTE: The output is taken off the U78 flip/flop which develops the pulse train from the data signal to the output where it switches from data line to output line at a TTL level.)

5. Verify video I/O problems before starting the next routine

JOB SHEET #3

G. Routine #6 — Checking video I/O

1. Connect the main board to the video system connector which supplies +12V at 1 Amp and also supplies (+12V comes in at pin #7) the video input signal at pin #8, the vertical sync on pin #9, and the horizontal sync on pin #6

   (NOTE: Pins #1, 3, and 10 are GND pins.)

2. Check all pins for proper voltages and then use an oscilloscope to check for proper waveforms as compared with those in Computerfacts

3. Use the oscilloscope to check for proper waveforms of the board on the video monitor assembly which is housed in the upper case and is easily accessible

   (CAUTION: When the case is open and the system is operational, the voltages in this area are potentially hazardous so work with care.)

   a. If everything appears to be okay, move on to the next check point

   b. If there are not voltages on the CRT device, check the F101 fuse which fuses the high voltage system and replace if required

4. Use an oscilloscope to check key components of the video signal

5. Check the video signal on pin #8 of the connector:

   a. Video input should appear at the input of Q302

   b. Video output should appear at the output of Q302

      (CAUTION: This is a video amplifier transistor with a 56.5V output, so this is not normal transistor voltage and you should work with care around this component.)

6. Check the vertical signal at pin #9

   a. Check the Q601 sync amplifier for an input of 15.7V

   b. Check the Q601 sync amplifier for an output of 15.7V

   c. If vertical sweep is not present, check the waveform heights and frequencies in the vertical sweep section and compare them against those shown in Computerfacts

      (NOTE: The vertical sweep section includes the vertical oscillator which is the Q602 transistor, followed by a Q603 preamp transistor, a Q604 driver transistor, and then two Q606 and Q607 push/pull output-type transistors for driving the deflection yoke on the CRT.)

JOB SHEET #3

7. Check the horizontal signal at pin #6

   a. Check the input of the Q701 transistor

   b. Check the output of the Q701 transistor

   c. Check the horizontal oscillator Q501 transistor

   d. Check the horizontal driver and the horizontal driver transformer

   (NOTE: Output from the horizontal driver transformer is used to drive the horizontal output transistor Q503, but do not take measurements here unless you have an oscilloscope probe designed for high voltage use because the Q503 should be running at extremely high voltages.)

8. Check other components in the horizontal control circuitry only with a high voltage probe

   (NOTE: The horizontal circuitry is used to drive the high voltage power supply system and that output goes to a high voltage transformer/rectifier, CR503 and T501.)

9. Refer to Computerfacts for information needed to check the controls for focus, vertical hold, and horizontal hold

10. Make a final reevaluation of all your procedures and findings before reassembling the microcomputer

    ☐ Power supply voltages are verified

    ☐ Interrupts and control lines are verified

    ☐ Clock and timing are verified

    ☐ System ROM is verified

    ☐ System RAM is verified

    ☐ System I/O's are verified

11. Reassemble the microcomputer

12. Sign off your troubleshooting log

13. Have your instructor check your work and discuss your findings with your instructor

14. Clean up the area and return tools and equipment to proper storage

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

NAME ____________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Using a current tracer to check for breaks in supply traces between power supplies and other components

_____b. Column address select

_____c. Dynamic ram

_____d. Row address select

1. CAS
2. RAS
3. D RAM
4. Backtracing

2. Complete the following statements concerning system characteristics of the Model III by inserting the word(s) or figure(s) that best completes each statement.

a. The system is built around a ____________ microprocessor

b. Depending on the version, it may have as low as 4K of ROM or as high as ____________ of ROM

c. Depending on the version, RAM may be as low as 4K or as high as ____________

d. Has a ____________ ____________ ____________ on board

e. May have one or two ____________ single-sided, double-density disk drives

f. Has a ____________ ____________ video system

g. May have an optional ____________ ____________ ____________ port so that a serial printer or a modem can be interfaced with the system

3. Complete the following statements concerning component characteristics of the Model III by inserting the word(s) or figure(s) that best complete each statement.

a. Has a standard 65-key ____________ keyboard that may or may not contain a numeric keypad

b. Keyboard is case mounted, but is ____________ to the main board

c. Drive circuitry for video is on ____________ ____________ ____________ ____________ which is housed along with the CRT in the upper case

TEST

d. Power supply is on a separate card with the power cable and power switch attached so that the power supply is ____________ ____________ ____________ ____________ ____________

e. The ____________ ____________ ____________ is also on a separate board that runs behind and parallel to the main board

f. Has a ____________ interface

4. Solve the following problems concerning troubleshooting guidelines for the Model III.

a. What is probably the most important part of disassembling a Model III?

Answer ____

____

b. What advice should be given to any technician working with the video section of the Model III?

Answer ____

____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

5. Demonstrate the ability to:

a. Disassemble a TRS-80® Model III microcomputer. (Job Sheet #1)

b. Troubleshoot the power supply on a TRS-80® Model III microcomputer. (Job Sheet #2)

c. Troubleshoot the main board on a TRS-80® Model III microcomputer. (Job Sheet #3)

TROUBLESHOOTING THE TRS-80®
MODEL III MICROCOMPUTER
UNIT XI

ANSWERS TO TEST

1. a. 4
   b. 1
   c. 3
   d. 2

2. a. Z-80
   b. 14K
   c. 48K
   d. Real time clock
   e. 5 1/4"
   f. Self-contained
   g. RS-232C serial

3. a. ASCII
   b. Cabled
   c. A separate PC card
   d. Not on the main board
   e. Floppy disk controller
   f. Cassette

4. a. To be careful with the CRT
   b. The video is unlike other systems because it's integrated, and there are dangerously high voltages in the video system and especially around the CRT

5. Performance competencies evaluated according to procedures written in the job sheets.

NOTICE

STAFF MEMBERS AND TECHNICAL ADVISORS HAVE WORKED TO MAKE THESE INSTRUCTIONAL MATERIALS EASY TO USE AND EASY TO READ. WE WELCOME YOUR INPUT IN THE FORM OF SUGGESTIONS AND/OR CORRECTIONS BY RETURNING THE ATTACHED POSTCARD WHICH HAS BEEN PRE-PAID.

THANK YOU.

Name of Publication______________________________

My overall rating of this publication is:

Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor ☐

I would suggest that to improve the materials, MAVCC should

____

____

Other comments ________________________________

____

(Optional)

Name_______________________________________

Address_____________________________________

____

NO POSTAGE
NECESSARY
IF MAILED IN
THE UNITED STATES

BUSINESS REPLY CARD

FIRST CLASS PERMIT NO. 266 STILLWATER, OKLAHOMA

POSTAGE WILL BE PAID BY

Mid-America Vocational Curriculum Consortium
Oklahoma State Department of Vo-Tech Education
1500 West Seventh Avenue
Stillwater, OK 74074-9990